Review Article

Lasers: An Emerging Trend in Dentistry

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Abstract

Lasers were well-known into the clinical dentistry with the hopefulness of rise above some of the fault created by the predictable techniques of dental procedures. Though its first research for dental function in the 1960s, the utilization of laser has elevated quickly in the last two decades. Currently, broad diversities of procedures are accepted using lasers. This review is aiming to describe the functions of laser in dentistry. Lasers are establishing to be effective in cavity preparation, soft tissues application, hard tissues application, diagnosis, laser activation and others. Based on expansion in adhesive dentistry and the production of minimum participation principles, lasers are capable of revolutionize dental diagnosis & treatments.

Keyword: Dentistry, Laser.

Introduction:

Laser use in dentistry was recommended about 35 years ago as a means of using energy produced by light to take away or modify hard tissues and soft tissues in the oral cavity. Lasers are an ellipsis for Light Amplification by Stimulated Emission of Radiation described by Einstein in 1917.[1] It was Theodore Maiman in 1960, who demonstrated Laser utility making use of a Ruby laser .In dentistry, in 1964 it were Sognnaes and Stern who used the Ruby laser to vaporize enamel dentin. The current levels speedy development of lasers, with dissimilar wavelengths and involved parameters may persist to have major force on the scope and impulsively practice of dentistry.[2] The radiation concerned in producing laser light is non-ionizing and does not create the similar effects credited to X-radiation. The Food and medicine management has approved the use of a variety of lasers as devices to get rid of diseased gingival tissues and for other soft tissue purposes, in the elimination of dental caries, as an aid in inserting tooth-colored restorations and as an attachment in root canal procedures, such as pulpotomies.[1] Some authors have give details the benefits of CO^2 laser treatment of oral surroundings. Clinical applications persist to increase, building laser use one of dentistry's most thrilling advances with exceptional patient benefits.[3]

Features:

The emitted laser has three characteristic features.

1. Monochromatic: in which all waves have the same frequency and energy.
2. Coherent: all waves are in a certain phase and are related to each other, both in speed and time.
3. Collimated: all the emitted waves are nearly parallel and the beam divergence is very low.

The wave differs in strength (which is amplitude of the swing frequency i.e. the number of times they vibrate, and length which is distance between their crest. The main differentiating characteristic of laser is wavelength, which depends on the laser medium and the excitation mode, for instance continuous wave or pulse mode.

Different wave lengths can be classified into three groups:

1. The UV range (ultra-spectrum approximately 400-700 nm).

2. The VIS range (visible spectrum approximately 400-700 nm).
3. The IR range (infra-red spectrum which is approximately 700 nm) to the microwave spectrum.[4]

Classification:

Lasers can be classified according its spectrum of light, material used, and hardness etc **(Table No. 1)**. Lasers are also classified as soft lasers and hard lasers.

Soft lasers are of cold (athermic) energy emitted as wavelengths; those are thought to stimulate cellular activity. These soft lasers generally utilize diodes and the manufacturers claim that these lasers can aid healing of the tissue, reduces inflammation, edema, and pain. Clinical application includes healing of localized osteitis, healing of aphthous ulcers, reduction of pain, and treatment of gingivitis.

The current soft lasers in clinical use are the:

- Helium-neon (He-N) at 632.8 nm (red, visible).
- Gallium- arsenide (Ga-As) at 830 nm (infra-red, invisible).

Hard lasers (surgical) can cut both soft and hard tissues. Newer variety can transmit their energy via a flexible fiber optic cable. Presently more common type clinically used, under this category the medical lasers are:

- Argon lasers (Ar) at 488 to 514 nm
- Carbon-dioxide lasers (CO2) at 10.6 micro-meter
- Neodymium-doped yttrium 6luminium garnet (Nd:YAG) at 1.064 micrometer.
- Indium-gallium-arsenide-phosphide-InGaAsP (diode)
- Holmiumyttrium-aluminum-garnet (Ho:YAG) at 2.1 micro-meter.
- Erbium,chromiummyttrium-slenium-gallium-garnet (Er,Cr:YSGG) at 2.78 micro-meter.
- Neodymiummyttrium-aluminum-perovskite (Nd:YAP) at 1,340 nm.[5,6]

Clinical Applications in Dentistry

Use of lasers on hard tissues

Lasers for caries detection: Despite the fact that laser fluorescence have confirmed good sensitivity and exceptional reproducibility to detect caries; it is unable to enumerate the degree of decay. Laser fluorescence too has proved on form for the detection of enduring caries. Although safety is not a matter of concern about this low-power laser application, further studies are essential to support the clinical interpretation of the results and to enlarge its clinically useful sense despite the limitations of this technology.

Lasers for removal of carious lesions and cavity preparation: Laser systems can be employed for successful removal of caries and cavity preparation with no significant thermal effects, collateral decay to structure of tooth, or patient's uneasiness. Er-based laser system can be used to achieve efficient ablation at such degree of temperature that is below the melting and vapourization temperatures of enamel. Up to now, diverse laser systems i.e. super-pulsed CO2, Ho:YAG, Ho:YSGG, Nd:YAG, Nd:NLF, diode lasers and excimers, have not demonstrated practicable to use for cavity preparation in general practice settings. Excluding caries exclusion, it's an array of other well recognized laser hard tissue procedures which contain desensitization of cervical dentine laser analgesia (using Nd:YAG, Er:YAG, and Er,Cr:YSGG lasers), (using Nd:YAG, Er:YAG, Er,Cr:YSGG CO2, KTP, and diode lasers), laser-enhanced fluoride uptake (using Er:YAG, Er,Cr:YSGG, CO2, argon, and KTP lasers).[7-12]

Laser Bleaching: In the month October in 1998, the ADA Council summarized that due to concerns about pulpal safety and a short of controlled clinical studies, the CO2 laser procedure have not been prescribed for tooth-whitening applications. The council put a light on, though the argon laser might be used as a suitable substitution for the traditional curing light but in the case of if suggested procedures are followed carefully by the manufacturer.[13]

Table No. 1: Classification of LASERS

Classification of LASERS		
Classification According to Material Used		
Gas	Liquid	Solid
Carbon dioxide Argon	Not so far in clinical use	Diodes Nd:YAG, Er:YAG, Er:Cr:YSGG, Ho :YAG
Classification Based on Light Spectrum		
UV Light	100 nm - 400 nm	Not used in dentistry
Visible light	400 nm to 750 nm	Most commonly used in dentistry (Argon & Diagnodent Lasers)
Infrared light	750 nm to 10000 nm	Most dental lasers are in this spectrum

Use of lasers on soft tissues

Laser curettage: The Nd:YAG and gallium-arsenide (or diode) lasers, both are advertised for curettage. A critical review done on the prominent accessible evidences that strongly suggests that there is no additional advantage to the patient when this process is applied after conventional mechanical scaling and root planing. Advocators of laser curettage associate with the capability of these lasers to kill microorganisms. Although the available data point out that this outcome is possible even though not consistent, it hasn't been linked with the upgrading in periodontal attachment level. Lacking verifiable benefits and with a noteworthy risk of collateral damage to the periodontium, laser curettage demonstrated to be neither scientifically nor ethically acceptable. Er:YAG laser contains appropriate characteristics for numerous surgical and non-surgical measures but randomized controlled clinical practice have to be promoted to confirm its prominence as an adjunct or substitute to traditional periodontal therapies.[14,15]

Lasers in Endodontics:

All the pre-clinical studies of laser-supported endodontic therapies have been the underpinning for the progress of a laser-supported endodontic remedial plan. Laser procedures have been integrated in the conventional endodontic therapeutic concept to indisputably improve conventional therapy due its specific bactericidal effect.[1] Clinical studies have brought to the advanced establishment based on therapeutic plan that is laser supported and have approved results to be confirmed over defined time duration sequentially to facilitate statements to be given about the success scenario of laser-supported endodontic treatments. GUTKNECHT et al. (1996) concluded a considerable fact that only 21 percent of challenging cases were able to receive treatment with success with no laser support, whereas 82 percent of

cases were effectively resolved with the support of Nd:YAG laser, after having been ineffectively treated earlier with traditional methods (medicinal inlays, CHKM, corticoids, diverse rinsing solutions and preparations, etc.).

According to their clinical practice and patient's follow-up results, it was further observed by the authors that the micro-organism decline, which is influential for successful therapeutic process must be evidently credited to the laser. The reported statistics, which has mentioned above, have to be evaluated as a significant result when observed concurrently to the multifaceted initial pathological condition and the strict selectivity which applied to cases. The probability of the fracturing of a preparation instrument is noticeably higher (3 to 4%).

One more positive facet of the laser treatments is that through this method it has been possible to even treat strappingly curved root canals and for those also which are only be prepared up to ISO 30. The released laser energy contains positive micro-organism decreasing effect still in the layers of dentine adjacent to the canal lumen and in the peri-apical area. On the contrary, rinsing solutions that is used in traditional disinfection process have almost no or only minor effects in such small lumina, possessing to their substantial limitations. This is particularly applicable to the problem of endodontic areas of the apical third. In general practice, a little more time is required for a laser treatment. However, a patients' expectation is very high due to its possibility to save the tooth. In between 1991 to 1992, 40% of the test cases were conducted; so that we can presume that such positive statements may also apply to the medium or long term post-treatment phase.

Applications:

The diagnosis which was obtained after anamnesis, clinical and radiological test forms the base for our clinical process. Vital extirpation is very helpful to remove the inflammatorily damaged tissue, if a bacterial infection of the crowns or root pulp, has not yet taken place which include any associated consequences. But, the situation is absolutely different if a strong bacterial infection of the endodontic system is diagnosed after having anamnesis and, clinical and radiological test. Then it may become a case of gangrenous changes in the endodontic system, which possess the special ecological setting that apply, some specific species are there that induce the picture of peri-apical periodontitis (SUNDQIST, 1993; PEREZ et al., 1993). In the desired therapy, which eliminates the pathogenic organisms to the extent that possible and results as a complete curing method of inflammation, it avoids re-infection and provoking osteoanagenesis. LEHNERT, 1993, stated that only very indecisive or no scenario of success for the conventional therapy of gangrenous teeth can be given.

Moreover, bacterial immigration of the root canal in addition to species spectrum, anatomic settings/conditions such as strongly curved, partly obliterated root canals and strong ramifications in the area of apical third of the root canal are strong enough to restrict therapeutic success. Consequentially it has become challenging for endodontics practitioners as initially, the non-invasive and more pleasurable methods should be pursued for the patient, before surgical intervention (LEHNERT, 1993, TETSCH, 1986, WASSMUND, 1935, MAALOUF et al., 1994).[16,17]

Lasers in Periodontics:

For the management of periodontal diseases, scaling and root planning is one of the best traditional methods for controlling subgingival microflora. The major purposes of subgingival debridement are to eradicate the adherent and unattached bacterial plaque as well as deposits of calculus also. On the other hand, elimination of calculus by the means of traditional hand instruments has been observed as incomplete and time consuming also. For the improvement of the efficiency and competence of root surface debridement, numerous devices like sonic and ultrasonic scalers, and recently invented lasers have been used. Many studies reported that sonic and ultrasonic instrumentation were found equally superior treatment outcomes, when compared with manual instrumentation.[18]

As the periodontium includes both of the hard and soft tissues, using lasers for periodontal treatment has been more complex. Along with many other available

lasers, high power lasers like CO2, Nd:YAG and diode lasers result far better in periodontics due to their outstanding soft tissue ablation and hemostatic qualities. Though they are used to be applied on the root surface or alveolar bone, thermal damage and carbonisation have been observed. Thus using these lasers is restricted to frenectomy, gingivectomy and similar soft tissue procedures which includes the exclusion of melanin pigmentation of gingiva.

Some of the laser like Er:YAG and Erbium-Chromium doped: Yittrium-Selenium-Gallium-Garnet (Er,Cr:YSGG), have been introduced recently and this laser scaling was also used as a substitute or an adjunctive to traditional scaling and root debridement. Among the available lasers, the level of absorption of the Er,Cr:YSGG and Er:YAG lasers in water is reported almost highest. These lasers efficiently remove all biologic tissues which contain water molecules. The erbium laser group has protruded as an effective laser system to diagnose periodontal indications.

Er:YAG laser is recommended for application in several clinical studies for periodontal treatment. Watanabe et al. observed a proficient calculus elimination without any side effects and ordinary diminution of pocket after Er:YAG scaling. Schwarz et al. stated that comparatively better results were found at six months later than laser treatment of periodontal pockets, they were compared to traditional mechanical debridement by the means of hand scalers and reported considerably higher decline of bleeding on penetrating scores and improvements were also seen in clinical attachment level after laser treatment. Schwarz et al. observed that nonsurgical periodontal treatment including laser alone or with a grouping of Er:YAG laser and scaling and root planning by means of hand instruments may found clinically and statistically considerable improvements in the clinical parameters without any difference between two treatments, later than 12 months after treatment.[19]

For the implant maintenance Er:YAG laser was also suggested, by taking benefit of its bactericidal or sanitization effect. The inflammation of the surrounding soft tissues and induction of the breakdown of the implant adherent alveolar bone is a result of Peri-implant infection. It is related to the existence of a subgingival microflora, which is considerably similar to that in periodontal pockets and it contains a diversity of Gram-negative anaerobic bacteria. Matsuyama et al. demonstrated debridement of implant abutment surface by using Er:YAG laser and observed successful elimination of plaque and calculus with no damage to the implant surface8. Kreisler et al. also reported a non-excessive heat generation on the implant surfaces and efficient sanitization using the Er:YAG laser.[20,21]

However, successfully done experimental results and clinical results have been observed far better than the Er:YAG laser, more studies are needed for better understanding the effects on periodontium to apply its safely and effectively in the course of periodontal treatment. Thus, randomised controlled clinical practice and more fundamental studies have to be promoted and applied to establish the most favourable and safest parameters for laser treatment.[22]

Lasers in Orthodontics:

The applications of different kinds of lasers in orthodontics are totally depend on the type of desired treatment and on the potential benefits of laser techniques over traditional methods. The major applications of lasers in orthodontics include holography, laser scanning, and applications on soft and hard tissues.[23]

Classical methods of acid etching involve using phosphoric acid (37%), in the form of a gel or solution, on the surface of enamel. The action-timing is between 15-60 s. The enamel seems mat, later than washing and drying. The alternative use of lasers is for conditioning of enamel which has ascertained for solving other problems also like:

a) Should the labial surface all over covered by acid, or only a small portion, which lies outside the base of the bracket?
b) What is the most favourable time for etching of acid?
c) Should the time be prolonged when teeth previously underwent fluoridization procedures?
d) Should the acid etching be allowed for teeth which show signs of total demineralization?

e) How much quantity of enamel is influenced by acid etching, and how much deep are the histological alterations? Are they reversible or irreversible?

The most tested, for enamel conditioning, are CO2 laser, Nd:YAG laser, Er:YAG laser, Excimer laser, etc. Present techniques subscribe to the tendency to find a "proper" laser in order to obtain a resistant and longlasting conditioning. Clinical studies have demonstrated clearly that pulsed CO2 laser etching techniques determine a very good conditioning of the human enamel (98.9%), in view of composite laminating, in comparison with the one achieved with phosphoric acid (98.5%). The authors indicate this method as being elective for enamel etching, in order to seal the pits and fissures. Another laser tested in this respect is the Nd:YAG laser. As in the case of CO2 laser, studies connected with the use of Nd:YAG laser for enamel etching were focused on resistance tests to the traction of orthodontic resins (auto and photo-polymerized), as well as on those connected with the resistance to tearing, after fixation of the bracket on the dental surface.[24-26] Thus, for laser etching, approximately 15 impulses are necessary, of 75 mJ/impulse. The enamel surface must be covered with the accelerating solution for laser radiation. The area will be irradiated until the complete evaporation of the accelerator.[27]

Roberts-Harry,[28] using the Nd:YAG laser for enamel etching, considered that the etching model is inferior to that obtained with phosphoric acid, but much more targeted, and the working time is more reduced. The use of Nd:YAG laser in this purpose, is without any risk of pulpal involvement. Practically, the subjects did not show any symptoms, even 3 years from the treatment, responding normally to vitality tests. The working regime for Nd:YAG laser ($\lambda = 1.06$ mm,) is directed through a quartz optical fiber (f = 320 nm). The power used reached aproximatively 1 W with 150 ms pulse duration. The studies of L. Corpas Pastor et al[29] add to the efficiency in laser conditioning with Nd:YAG laser; they recommend the use of laser power up to 2 W, 133 mJ/impulse, 15 Hz, and 60 s time of interaction. Presently, the Er:YAG laser (l = 2.96 mm), tested by some researchers, is the most used laser in conditioning enamel surfaces.[30]

Orthodontic treatment along with ceramic brackets is very often used these days due to esthetical reasons. The major problems of this treatment take place when the brackets are detached from the teeth as they can cause fractures and ruptures in enamel as well as in the brackets. But nowadays the process of ceramic brackets has upgraded its system of attachment with a bonding gule/cement, from chemical towards the mechanical. This program has presented with the procedure of testing as well as with the introduction of electrothermal detaching. Strobl[31] and Tocchio[32] demonstrated the first data which are referring such differences which take place in the course of the procedure of detaching the brackets with CO2 and YAG lasers. Tocchio et al have reported the comparison in between the actions of detachment of the poly-crystalline alumina brackets and those which made of crystalline alumina. The process of detachment was initiated by applying a twisting force for two seconds from the irradiation.

In general practice, the procedure of thermal softening of the enamel appeared as the main mechanism. The heat to the labial surface of the bracket is induced by the laser, and an increased temperature was transmitted via bracket to the resin. In the case of teeth-correction with overstate of rotations, Fibrotomy is performed particularly, along with anterior maxillary and mandibular teeth, like the greater lateral incisors, in class II, subdivision 2. This fibrotomy maneuver is recommended later than a slight hypercorrection of 3-50 taken place. A continuous CO2 laser 1-3 W is not only often suggested, but Nd:YAG laser of 1.75-3 W also. A continuous CO2 laser of 5 W powers is generally used. Thus the line of incision is precised, and the risk of infections becomes absent. CO2 laser used in pulsed mode can also be used for etching the surfaces of enamel of the open tooth, which followed by application of anchorage bracket. The method is comparatively much better as the enamel etching is also achieved in the state of bleeding. The Nd:YAG laser, 20-30 impulses, with 1.75-3 W/ impulse is also recommended. Plaque gingivitis, 86 which is a direct result of preservation of bacterial plaque in

orthodontic patients, they can also take advantage from laser therapy.

The lasers which are tested incidentally are CO2 and Nd:YAG lasers, as they have proved their ability in the destruction of bacterial plaque. Continuous CO2 laser ($\lambda = 10.6$ mm), with a power of 1-2 W, used in defocused condition, may give a advantageous result in the removal of bacterial plaque. The use of LLLT is quoted as a state-of-the-art method in some specific literature, like the GaAlAs diode or the He-Ne laser.

The removal of surgical epulis and plaque hyperplasia (following a non-sterile and imprecise uncovering of the canine) can be done by laser sectioning. Benhatit and Naumural use the CO2 laser of 5W (continuous mode) for gingival sectioning. The benefits of this method includes declining the bleeding and inflammation, precision of incision, great visibility, lessening time of working, hygienic working setting because of no direct contact with the instrument, quick healing without infections. Nd:YAG laser, 20-30 impulses of 1.75-3 W/impulse is recommended by Bradley and Arcoria, even in the absence of anesthesia. This has proved advantageous because the use of laser fiber would make it very precised, fine, and reduce the pain.

White et al indicate the conditions that responded positively to laser therapy which based on a comparative study (scalpel-Nd:YAG laser) in this regard. The base for using the method of pain reduction is a result of orthodontic adjustment, through LLLT, which were set by Hong-Meng, Kenneth and David[33]; the patients residing in the Singapore were chosen for testing this therapy. They were aged between 21 and 24 years, with a presence of integral dental arches, with covered proximal areas, and with at least one premolar on each half arch. It was required that no tooth related conditions that could produce acute or chronic inflammations. The GaAlAs diode (class 3B, Laser System International, Egedalsvej, Vekso) laser was used.

Some other low-energy laser systems which were used in other investigations, consist of Panalas-4000 (Japan medical Laser Laboratory and Matsushita Electric Co., Tokyo, Japan), and Proton Plus (Ronvig Instruments, Daugaard, Denmark). The studies have reported the similar conclusions which are as follows: the above lasers can assured the declining of pain resulting to the orthodontic adjustment. Advantageous results were found in the second and third day from the treatment. This result is corresponding to clinical interpretation of specialists in orthodontics, who reported the maximum of pain curve on 3rd day. In general practice, by means of GaAlAs laser probe, for 30-60 s, for 2-3 sessions, the pain can be reduced at a great extent, even completely removed.

Conclusion:

Lasers are supported by more than 35 years of research, development and exploration by numerous clinicians and companies, laser dentistry is ingoing a new age of legitimacy, fuelled by the adaptability and broad efficacy of the laser.

To be taught more concerning the lasers in general, there are seminars and symposiums existing through the "World Clinical Laser Institute", in addition educational content & CDs or DVDs available from dentists using the laser.

The apex of the research and exploration has effected in the laser, which offers the lots of capabilities across all regulations in dentistry. Today's dentist has a chance to incorporate laser technology, which can allow him or her to execute dentistry with enhanced clinical results, more patient console, and faster healing.

Laser technology can really expand the ability of a dentist to speak the clinical needs of the patient, and do additional procedures both clinically & cosmetically.

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