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Lasers in Dentistry: An Innovative Tool in Modern Dental Practice

Dr. ArkaJyoti Chakraborty[(1)], Dr. Devendra Chaudhary[(2)], Dr. Harmeet Singh Sachdeva[(3)], Dr. Neha Singh[(4)], Dr. Priyadarshani Khadase[(5)], Dr. K. V. Swarna[(6)]

Post Graduate student, Dept. of Conservative Dentistry & Endodontics, Maharaja Ganga Singh Dental College and Research Centre.
Professor and Head of Department, Dept. of Conservative Dentistry & Endodontics, Maharaja Ganga Singh Dental College and Research Centre.
Reader, Dept. of Conservative Dentistry & Endodontics, Maharaja Ganga Singh Dental College and Research Centre.
Post Graduate student, Dept. of Oral & Maxillofacial Surgery,Surendera Dental College and Research Institute.
Post Graduate student, Dept. of Oral & Maxillofacial Surgery, Maharaja Ganga Singh Dental College and Research Centre.
Post Graduate student, Dept. of Conservative Dentistry & Endodontics, Maharaja Ganga Singh Dental College and Research Centre.

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I. INTRODUCTION

The word Laser stands for 'Light Amplification by the Stimulated Emission of Radiation'. Laser is the brightest monochromatic (single colour) light existing today. Laser was invented by Dr. Maiman in 1960. Laser has found widespread application in communications industry, defence and medicine. Lasers are the single most important advancement in surgery of the 20th century. These versatile devices have evolved from the early short pulsed lasers to the more sophisticated continuous wave gas and solid state lasers.

Lasers have become extremely important either as an adjunct tool or a treatment devices in dental field. They have a variety of applications both in soft and hard dental tissue treatments. It is therefore crucial for the clinician to have an understanding of laser basics. In 1956, Thomas Maiman exposed an extracted natural tooth to his prototype Ruby (694 nm) laser; the nature of the wavelength and target chromophore, together with the laser power resulted in charring of the hard tissue element and transmission of laser energy to the tooth pulp. (1)

Following the early clinical experiences of Goldman and others such as Polanyi and Jako in the 1960s, the development of Argon, Neodymium (Nd) YAG and Carbon Dioxide lasers in general areas of surgery led to a gradual introduction of these wavelengths in surgical procedures in the mouth. These early lasers have continuous-wave emission mode, which gave rise to potential for conductive heat damage. This was addressed by the introduction of pulsed-emission lasers, which allowed selective destruction of abnormal or diseased tissue, while leaving surrounding normal tissue undisturbed. The first lasers to fully exploit this principal of 'selective thermolysis' were the pulsed dye lasers introduced in the late 1980s.

The possibilities for laser use in dentistry did not occur until 1989, with the production of the American Dental Laser for commercial use. This laser, using an active medium of Nd: YAG. (2)

Various laser types (Nd:YAG, Er,Cr:YSGG, Er:YAG, CO_2) having corresponding wavelengths(1064nm, 2780nm, 2940nm, 10600nm) are becoming available to dentists to address their needs for hard and soft tissue treatment procedures. Soft tissue lasers [near infra red (NIR)] are characterized by a high absorption in chromophores (hemoglobin and melanin) found in soft tissue, resulting in excellent soft tissue incision, ablation and coagulation performance as well as antimicrobial effectiveness, due to relatively deep highly localized tissue heating. Hard tissue lasers [Far Infra Red (FIR)] are highly absorbed in (carbonated) hydroxyapatite and water chromophores and are thus able to finely ablate hard tissues without heating of the surrounding tissue. (3)

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In 1989, experimental work by Keller and Hibst using a pulsed Erbium YAG (2,940 nm) laser, demonstrated its effectiveness in cutting enamel, dentine and bone. This laser became commercially available in 1995 and, shortly followed by a similar Er,Cr:YSGG (erbium chromium: yttrium scandium gallium garnet - 2,780 nm) laser in 1997, amounted to a laser armamentarium that would address the surgical needs of everyday dental hard tissue treatment. (4)

All dental lasers exert their desired clinical effect on a patient's target tissue by a process called absorption. This target may consist of hard tissue, including natural tooth structure, carious enamel and dentin, dental calculus, bone, or even an existing defective composite restoration within the tooth. Many different types of intraoral soft tissue targets commonly are observed upon routine examination, such as redundant gingival tissue, aberrant frenum, operculum, epulus, or benign lesions in the form of a fibroma or a papilloma.

Dental lasers function by producing waves of photons (quanta of light) that are specific to each laser wavelength. This photonic absorption within the target tissue results in an intracellular and/or intercellular change to produce the desired result.

Dental lasers offer a number of clinical advantages (especially for soft tissues), including hemostasis (the sealing of local vasculature), the ability to seal nerve endings and lymphatic vessels, reduced postoperative pain and swelling (thus reducing the need for postoperative analgesics/narcotics), reduced bacterial counts, and a minimized need for sutures in most surgical procedures. (5)

PHYSICS OF LASERS

Spontaneous emission**(Figure 1.)** occurs when atoms are excited to a higher energy state, their electrons occupy excited orbits, but spontaneously drop to a ground state orbit with the concomitant release of a packet of energy called a photon.

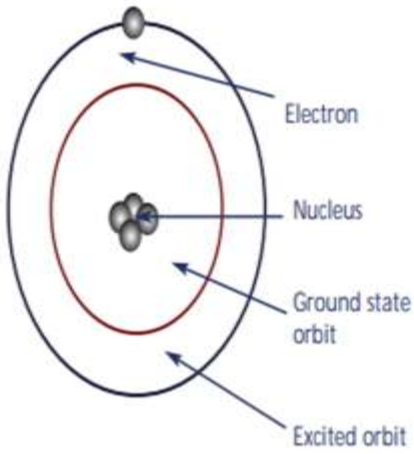

Figure 1: Spontaneous Emission

Stimulated emission occurs when atoms are energised by heat, light or electric discharge. In a laser, the pumping source supplies this energy to an optical cavity (resonator), which contains excitable atoms (the lasing medium). As these decay, they release photons of energy. The optical chamber is lined by a totally reflecting mirror on one end and a partially reflecting (partially transmissive) mirror at the other end, resulting in photons 'resonating' from one end to the other, with some escaping through the transmissive mirror. As the 'pumping' from the energy source continues, the number of excited atoms in the medium exceeds the number of ground state atoms. This is called a population inversion. Some excited atoms decay spontaneously to create free photons. These interact with other excited atoms without being absorbed, which then releases another photon before returning to the ground state. For lasing to occur, the incident photon must carry on with the same wavelength and be in phase with the emitted photon. (6)

TYPES OF LASERS

The main types of lasers used in dentistry are the diode laser (810nm–980nm), CO2 (Carbon dioxide, 10600nm) and the YAG family (2100nm – 2940nm) ieErYAG (Erbium Yttrium Aluminium Garnet), ErCrYSGG (Erbium Chromium Yttrium Selenium Gallium Garnet), and HolYAG (Holmium Yttrium Aluminium Garnet). These feature predominantly as hard tissue lasers. NdYAG (Neodynium Yttrium Aluminium Garnet) is an effective dental laser wavelength in soft tissue procedures but doesn't feature commonly in many of the units on the British market.

SOFT TISSUE LASERS:

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Soft tissue lasers	Wavelength
Alexandrite	377 nm
Argon	488 nm, 514 nm
KTP	532 nm
HeNe	632 nm
GaAI	820 nm
GaAIAs	830 nm, 980 nm
Nd:YAG	1,064 nm
Nd:YAP	1,340 nm
Ho:YAG	2,120 nm

Table 1. Different types of soft tissue lasers

There are specific soft tissue indications for the clinical use of lasers, including anterior gingival estheticrecontouring, gingivectomygingivoplasty(for crown lengthening procedures), operculectomy, removal of epuli, incisions when laying a flap, incision and drainage procedures, frenectomy, vestibuloplasty, coagulation of extraction sites, treatment of herpetic and recurrent aphthous ulcer lesions, uncovering of an implant, pre-impression sulcular retraction, and ablation of an intraosseous dental pathology (such as a granuloma or an abscess). Other excisional laser procedures involve the removal of soft tissue targets that may appear as benign lesions (such as fibromas or papillomas) on the lip, tongue, buccal mucosa, or palatal area; the removal of coronal pulp as an adjunct to root canal therapy; excisional biopsy; and sulcular debridement.

Diode (810 nm, 940 nm, 980 nm, 1,064 nm), Nd:YAG (1,064 nm), CO_2 (10,600 nm), Er:YAG (2,940 nm), Er,Cr:YSGG (2,780 nm), and potassium-titanyl-phosphate (KTP) (532 nm) lasers are the wavelengths used most commonly for soft tissue procedures. Diode and Nd:YAG lasers are alike in that these lasers are absorbed in pigmented tissues (melanin and Hb) and both wavelengths are transmitted to their targets in contact with a thin flexible quartz fiber.A diode laser can be used for clinical scenarios in which an aberrant frenum pull causes recession and a loss of attached gingiva.
Er:YAG laser can be used to desiccate the marginal gingival tissues adjacent to vital finish lines prior to taking final crown and bridge impressions.(7)

HARD TISSUE LASERS:

Hard tissue lasers	Wavelength
Er,Cr:YSGG	2,780 nm
Er:YAG	2,940 nm
CO_2	9,300 nm; 9,600 nm; 10,600 nm

Table 2. Different types of Hard tissue lasers

Cavity preparation using lasers has been an area of major research interest since lasers were initially developed in the early 1960s. At the present time, several laser types with similar wavelengths in the middle infrared region of the electromagnetic spectrum are used commonly for cavity preparation and caries removal. The Er:YAG, Er:YSGG and Er,Cr:YSGG lasers operate at wavelengths of 2940, 2790, and 2780nm, respectively. These wavelengths correspond to the peak absorption range of water in the infrared spectrum, although the absorption of the Er:YAG laser (13,000cm^{-1}) is much higher than that of the Er:YSGG(7000cm^{-1}) and Er,Cr:YSGG (4000cm^{-1}). Since all three lasers rely on water based absorption for cutting enamel and dentine, the efficiency of ablation (measured in terms of volume and mass loss of tooth structure for identical energy parameters) is greatest for the Er:YAG laser.(8)

At present, Erbium lasers are the only hard tissue laser wavelengths available commercially. The main chromophore for Erbium lasers is water, although they also are well absorbed in carbonated hydroxyapatite, a component of natural tooth structure and bone. These inherent absorption qualities allow erbium lasers to ablate tooth and bone. Erbium lasers are unique in that they are the only lasers that can cut both hard and soft tissues. The Erbium lasers' ability to remove composite restorations is due to their photonic absorption in the water. Hard tissue ablation results from microevaporative expansive events that occur within the target due to an extremely rapid build up of heat and spontaneous evaporation of the available water content.(7)

CLINICAL APPLICATIONS OF LASER IN OPERATIVE DENTISTRY:

Lasers in Diagnostics

Traditionally, clinical examination with dental mirror and probe has been used for caries diagnosis.

The use of an explorer when there is an area of white or opaque enamel may produce irreversible defects in occlusal fissures. The use of bitewing radiographs for occlusal caries diagnosis has been questioned, due to the lack of accuracy in detecting enamel occlusal lesions.(9)

Diagnodent:

A new method based on fluorescence measurements performed by a laser device has been growing in popularity during the past three years. When the laser irradiates the tooth, the light is absorbed by organic and inorganic substances present in the dental tissues, as well as by metabolites from oral bacteria. These metabolites could be porphyrins that are produced by several types of oral bacteria. Studies using chromatography have found that porphyrins showed some fluorescence after excitation by red light. For this reason, the dental tissue emits fluorescent light after irradiation by red laser and, as the carious tissue increases the emitted fluorescent light compared to healthy tissue, this causes a significant difference between carious and sound structures. The performance of the laser device has been reported by several in-vitro and few in-vivo studies. However, the results varied substantially. While some studies have shown good performance, others have found low values of specificity.(9)

Laser Doppler Flowmetry:

Laser Doppler flowmetry (LDF) or laser Doppler velocimetryhas been extensively used in medical and dental research. LDF is a non-invasive technique widely used in haemodynamic research for assessing microvascular blood flow, in particular, to partially quantify blood flow in human tissues such as the skin, dental pulp, vessels, etc. This method might also be applicable in longitudinal studies if standardised procedures are used to improve reproducibility.

LDF was firstly demonstrated by Maiman, in the year 1960. Then a method of measuring the velocity of particles in solution using the Doppler frequency shift of backscattered light was suggested. Over the years, this technique was used to measure the velocity of red blood cells in a glasstube flow model. More recently, it has been applied in the investigation of blood perfusion in the undisturbed microcirculation. Its sensitivity claimed is 85%. Recording the pulpal blood flow would be an objective assessment of the status of the pulpal blood circulation, a true indicator of pulp vitality.

The LDF evaluates blood flow in capillaries. It works with a low power light from a monochromatic (single-wavelength) stable laser that is scattered by moving red blood cells and, as a consequence, has its frequency shifted. The laser beam has a penetration depth of approximately 1 mm in a hemispherical fashion, the capillary diameters are 10 µm and the velocity spectrum measurement is typically 0.01 to 10 mm/s. The light is partly absorbed and partly reflected. Moving particles, mainly erythrocytes, cause a Doppler shift in the reflected light. This change in frequency is converted to a laser Doppler flow signal, which is linearly related to microcirculatory blood flow.

A blood flow measurement is based on the processing of photodetected frequency-broadened light and laser light scattered from static tissue.

For this purpose, there are two optical fibres in laser Doppler probes: one is used to deliver light to the tissues, and the other is used to collect the scattered light. The signal is commonly recorded as the concentration and velocity (flux) of cells using a term ‘perfusion units’ where 2.5 V of blood flow is equivalent to 250 PU.(10)

Caries Prevention

The possibility of increasing the enamel resistance to demineralization after laser irradiation was first demonstrated in **1965** with a ruby laser **(Stern &Sognnaes 1972)**. Over time and with the increasing knowledge about the interaction of laser with hard tissue, the effect of CO_2 laser was tested. As good results relating to the inhibition of incipient caries were observed with this laser and as it provides a very efficient interaction with the tissue, this laser has been preferentially studied.(11)

Cavity Preparation

In restorative dentistry, laser has been used successfully for cavity preparation (De Moor et al., 2010; Obeidi et al., 2009), caries prevention (Namoour et al., 2011; Rechmann et al., 2011; Zezell et al., 2009), caries decontamination (Namour et al., 2011) and caries removal (Neves et al., 2011; White et al., 1993). For that, high intensity lasers are indicated, which are able to promote controlled temperature rise in a small and specific area of dental hard tissue (Ana et al., 2007). Depending on the temperature rise and the interaction of laser irradiation with dental tissues, it is possible to produce specific micro structural and/or mechanical changes related to a correct clinical application.

The use of lasers for cavity preparation and caries removal is based on the ablation mechanism, in which dental hard tissue can be removed by thermal and/or mechanical effect during laser irradiation (Seka et al., 1996). This mechanism relies on the type of tissue to be irradiated, as well as the characteristics of laser equipments. The knowledge of laser wavelength, laser emission, pulse duration, pulse energy, repetition rate, beam spot size, delivery method, laser beam characteristics (Ana et al., 2006), and optical properties of the tissue, such as the refractive index, the scattering coefficient (μs), the absorption coefficient (μa), and the scattering anisotropy are necessary for better clinical results without thermal or mechanical damages to the dental hard tissue. (12)

For irradiation in dental hard tissues, the most frequent laser systems used are Nd:YAG λ = 1.064 μm), Argon (λ = 0.488 μm), Ho:YLF (λ = 2.065 μm), Ho:YAG (λ = 2.100 μm), Er:YAG (λ = 2.940 μm), Er,Cr:YSGG (λ = 2.780 μm), Diode (λ = 0.810 μm) and CO2 (λ = 9.300 μm or 9.600 μm or 10.600 μm). With the exception of the argon laser, these lasers emit in infrared range of electromagnetic spectrum, and a good number of equipment operates at the free running mode, with pulse durations of microseconds (μs). Considering that laser wavelength must be absorbed by enamel and dentin to assure the efficient caries removal and cavity preparation (Seka et al., 1996), the most successful laser systems for this purpose are Erbium and CO2 (λ = 9.6 μm) lasers. However, the CO2 (λ = 9.6 μm) systems are not commercially available for applications in dentistry.

Effect of Laser on Surface Energy of Enamel

From the studies conducted for the evaluation of enamel resistance, outstanding mechanisms were discussed to be effective in the resistance of the enamel to acid. Below are some of these hypotheses:

- Some emphasized on melted surfaces and crater-like holes 1-20 µm in diameter in the Carbon Dioxide Laser (CO2) laser and Nd:YAG laser groups. They also reported positive birefringence and reversal of birefringence after acid challenge of the lased enamel.
- Another finding was improvement in crystalinity after Er:YAG ablation. Although others supported an increase in fluoride uptake and a reduction in acid dissolution, Erbium, Chromium Doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) (6/8 W, 6 sec) showed no significant Ca/P weight ratio changes, no enamel and dentin smear layer, various microirregular patterns, opening of dentinal tubules were clearly visible and no melting or carbonization was seen. (13)

Composite Photopolymerization

Light activated resin composites and curing lights for their photopolymerization have rapidly changed since first being introduced into clinical use. Although light cured composites are excellent for aesthetics procedures, both the physical and chemical properties of filled resin composites are directly related to their degree of conversion. Characteristics, such as composition of composite material, brand and shade, cavity preparation geometry and composite layer thickness, light intensity and polymerization time, can modify the final properties of material. Adequate polymerization of the composite materials is fundamental for optimal physical and chemical properties and best clinical performance. The depth of cure for composite materials can be affected by several factors associated with the source of light polymerization, including spectral emission (wavelength distribution), light intensity, exposure period, irradiation distance and composition of composite material. Incomplete cure of the material leads to lower mechanical properties and wear performance; leakable residual monomer and colour stability may decline as well.(14)

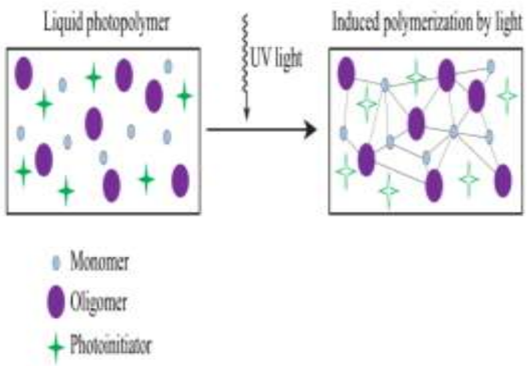

Figure 2: Photopolymerization

Visible light curing materials generally contain a diketone type photoinitiator that absorbs light in the 400-500 nm range and is covered with blue light from the visible spectrum. The most common photoinitiator used is camphorquinone (CQ), which has a peak absorption maximum at 468-470 nm. A primary factor affecting polymerization of resin composite includes the physical composition of the material, specifically the type and concentration of photoinitiators.

Standard halogen curing unitsproduce white light, whichmust be filtered to emit only the blue spectrum of visible light. To generate blue light, the lamps must beheated to very high temperatures, resulting in theemission of heat through the curing light tip.Thisheat transmission to the material may be responsiblefor the higher depth of cure, because heat increasesmobility of the monomers, thus increasing the probability of the occurrence of conversion.

The laser's beam implies stimulated emission of radiation and differs from the conventional light source. It is a single wavelength (monochromatic), collimated (very low divergence), coherent (photons in phase) and intense. Since the early 1980s, one research focus has been to use the argon laser for photopolymerization of resin composite restorative materials. This interest has arisen because the wavelength (488 nm) of light emitted by the argon laser is optimal for the initiation of polymerization of resin composites. The parameters of conventional halogen units are not uniform during their lifetime. Bulbs, reflectors and light tips degrade and filters become baked from heat generated by the units, which leads to a slowly altered spectrum of light. Because of the properties of the argon laser, resin composite polymerization is greater with this laser than when standard curing units are used. However, there is also a higher temperature rise and polymerization shrinkage.(14)

Argon is a single wavelength (monochromatic), collimated (very low divergence), coherent (photons in phase) and intense. Since the early 1980s, one research focus has been to use the argon laser for photopolymerization of resin composite restorative materials. This interest has arisen because the wavelength (488 nm) of light emitted by the argon laser is optimal for the initiation of polymerization of resin composites. The parameters of conventional halogen units are not uniform during their lifetime. Bulbs, reflectors and light tips degrade and filters become baked from heat generated by the units, which leads to a slowly altered spectrum of light.

Because of the properties of the argon laser, resin composite polymerization is greater with this laser than when standard curing units are used. However, there is also a higher temperature rise and polymerization shrinkage. Temperature rise problem. Pulsing can be precisely controlled in nanoseconds. Interrupting the laser beam allows the target material to cool between laser pulses, thus preventing overheating. (15)

Dentin Hypersensitivity/Desensitization

Dentin hypersensitivity has been defined as a short, sharp pain arising from exposed dentin in response to stimuli, typically evaporative, tactile, osmotic or chemical, which cannot be ascribed to any other form of dental pathology. The prevalence of dentine hypersensitivity has been reported ranging from 4 to 57%. In patients affected by periodontitis, dentine hypersensitivity prevalence was even higher ranging between 60 to 98%.

Brannstorm's hydrodynamic theory is most widely accepted as an explanation of tooth sensitivity. According to this theory, the exogenous stimulus applied to the exposed dentinal surface results in the flow of dentinal tubular fluid, activating the intradentalnerves present in the pulp to create pain. It generally involves the facial surfaces of teeth near the cervical margin and is very common in premolars and canines. (16)

In the last fifteen years, the introduction of lasers gave further possibilities to dentine hypersensitivity therapy. Focusing on the role of laser in dentine hypersensitivity therapy,it is possible to show that its action is two fold. By one side, the low level power lasers, also called "soft lasers," act directly on nerve transmission, with a depolarization process that prevents the diffusion of pain to central nervous system; however, their effectiveness seems poorer in higher degrees of dentine hypersensitivity.

By the other side, high power lasers such as: diode 980 nm and 808 nm, KTP 532 nm, Nd: YAG 1064 nm, CO2 10600 nm, Er, Cr: YSGG 2780 nm, and Er: YAG 2940 nm act on dentine hypersensitivity provoking a melting effect with crystallization of dentine inorganic component and the coagulation of fluids contained into the dentinal tubules. Among these "high power" devices, diode lasers are the most studied and the ones that gave the best results in several clinical protocols even in high grade dentine hypersensitivity cases. (17)

Bleaching

The terms "whitening" and "bleaching" are often used interchangeably, which can lead to confusion when interpreting the literature. According to the **USFood and Drug Administration (FDA)**, whitening restores teeth to their natural tooth colour, whereas bleaching makes teeth lighter than their natural colour. In other words, whitening refers to the removal or decolourizing of external stains on the surface of teeth, for example, by means of polishing agents in dentifrices, whereas bleaching is concerned with changing coloured substances within tooth

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structure (internal or intrinsic stains), for example, using reactive oxygen species (ROS).(18)

During the sixties and seventies, carbamide peroxide was used as an oral antiseptic, with an additional whitening effect discovered during treatment. This phenomenon was subsequently analysed by **Klusmier(1960)**. **Haywood and Heymann** later developed the original home bleaching process. The first commercial products were launched on the market as **White & Brite by Omni (1989)**.(19)

The first description of professional bleaching of discoloured teeth was provided by **M'Quillen in 1867**. This led in **1895** to the first commercial bleaching product, **pyrozone**, which was a mixture of five parts of 25% hydrogen peroxide (HP) and one part of diethyl ether.[18]

There are two methods of laser bleaching. One is the photothermal bleaching which is also known as the "power-bleaching". Photothermal is a process of transformation of absorbed light energy to heat leading to a local temperature increase. Photothermal bleaching is activation of a gel using high intensity light source (laser) that give controlled heating of the gel and break down the peroxide compounds within it. Another type of laser bleaching is the photochemical. Photochemical interaction induces chemical effects and reaction within the macromolecules or tissue. Photochemical bleaching uses the visible light energy to directly energize oxygen molecule.(20)

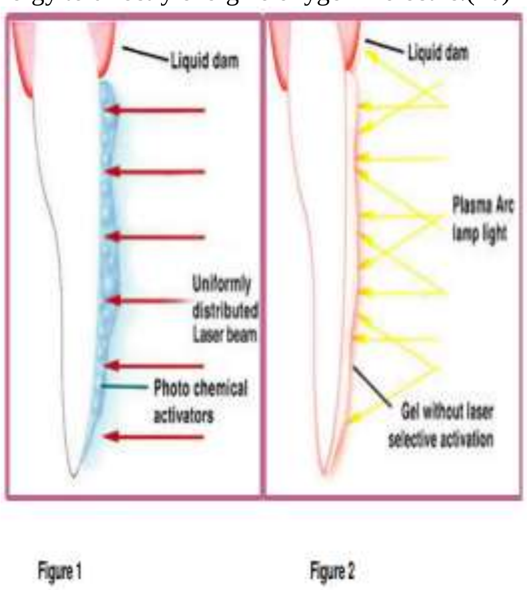

Figure 3. Difference between laser and non-laser whitening system

There are 3 dental lasers that have been cleared by **Food and Drug Administration (FDA)** for tooth whitening: argon laser, CO_2 laser and diode laser. But there are other lasers that have been tested for teeth whitening.

Photothermal bleaching uses a high energy laser. The most common type of laser for photothermal bleaching is the blue light diode laser (810-980 nm) and CO_2 laser (10600nm).
The other lasers studied in photothermal bleaching are CO_2 laser, Nd:YAG laser (1064nm), Alexandrite laser (750nm) and Er:YAG laser (2940nm).(20)

CLINICAL APPLICATIONS OF LASER IN ENDODONTICS:

Root Canal Sterilization

Since bacteria are the most important causeof periapical infections, the main objective inendodontic therapy is the disinfection of the rootcanal and the three-dimensional network ofdentinal tubules. From the infected pulp tissue,bacteria can penetrate into the deeper layers ofroot dentine and propagate a periapicalinflammation with subsequent destruction of the adjacent connective tissue.

The localmicroenvironment favours the selection ofrelatively few bacterial species, which can surviveand proliferate, being out of reach of the host's immune response.

The conventional chemomechanical treatment for canal preparation andenlargement does not result in complete bacteriaremoval. The pathogenic microorganisms are ableto penetrate the root dentine up to a depth of morethan 1 mm, whereas disinfecting solutions reach adepth of only approximately 100 µm. Very oftenthe apical third of root canal remains insufficientlyprepared, meaning that a smear layer made ofdentin debris, pulp residue and bacteria may befound in it. Irrigation of smear layer from thedentinal tubules may be impossible, so the needfor a new method to make endodontic treatmenteasier and more successful has become increasingly important.

Most currently use of irrigants and intra canal medicaments have limited anti-bacterial spectrum and a limited ability to diffuse into the dentinaltubules (100µm) therefore newer treatment strategies should be considered to eliminate microbes from the root canal system which penetrate upto 1,110µm. Laser light which penetrates up to >1000µm into the dentin thus has scope for complete root canal sterilization.(21)

The laser is an effective tool for killing microorganisms because of the energy and wavelength characteristics.

The laser light that attacks the bacteria may differ strongly from the light emitted by the fiber tip. This is because the light may have had an

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interaction with the dentin. Bactericidal effect of laser is attained by causing changes in bacterial cell wall. Because of the complex three layer membrane, gram negative bacteria are very sensitive to irradiation, and only very small densities of energy result in severe damage to the cell membrane of bacteria. An indirect irradiation with 1W causes obvious changes to the cell membrane of bacteria. A number of large, vesicle formations of different sizes can be observed (so called membrane blebbing) which covers the bacteria totally or partly. The blebbing phenomenon is the result of the inner layer of the membrane splitting from the two outer layers. This change of the cell membrane impacts upon the barrier function and since the cell coat is also the site of a most diverse enzyme system; one can also assume that a slight restructuring of the membrane disturbs the cell's metabolism substantially. In E. coli the changes of the murine – lipoproteins increase the sensitivity against EDTA and various other detergents, and changes also caused the loss, through the membrane, of periplasmatic enzymes like ribonuclease (this enzyme is involved in the reduplication and repair synthesis of the DNA).In comparison, the gram positive micro-organisms showed a higher resistance against irradiation. The reason seems to be the simple structure of the cell membrane. The cell wall of the gram positive E. faecalis shows an astonishingly high resistance against the laser irradiation. Low energies (1W) show almost no changes to these problematic bacteria. (21)

With the application of multiple irradiations, visible damage of the bacteria can be detected, but there can still be a few unaltered cells. However, the quantitative bacterial death increases steadily, and the damage seems to depend on a cumulative effect. A cellular stress factor leads to sub-lethal, reversible changes, but when the cell is hit again by the irradiation it dies. This mechanism is called the "knock on" effect.

II. DISCUSSION

The word laser represents an elegant acronym as "**Light Amplification by Stimulated Emission of Radiation**". It was demonstrated for the first time by **Theodore Maiman** in **1960** with various laser types (Nd: YAG, Er,Cr: YSGG, Er: YAG, CO_2)having corresponding wavelengths (1064nm, 2780nm, 2940nm, 10600nm) becoming available to dentists for their needs for hard and soft tissue treatment procedures. The removal of enamel and dentin by means of laser leads to thermal side effects. This fact was determined by **Sterns (1964)** who proved that until new ways of radiation production are introduced, laser will prevail with very strict limitations. The prognosis of Stern remained valid for more than a decade, until other lasers with a more favorable wavelength were introduced. The removal of enamel and dentin with no thermal side effects was possible once the superpulsed $CO_2$was introduced. However during caries removal with this, cooling with water is indicated with no loss in laser intensity. In contrast to this Er:YAG, Cr:YSG lasers have advantage of reducing thermal effects. Laser treatment is contact free and has advantages over rotary instruments such as, direct cooling of the area with water spray, absence of drilling sound, pressure, pain, temperature and anesthesiacan be omitted.

Lasers have been used as adjuvant treatment in both low intensity laser therapy and high intensity laser treatment, to optimize the outcome of clinical procedures. Low-intensity laser therapy induces analgesic, anti-inflammatory and biomodulation effects at molecular level with photochemical responses improving tissue healing processes and less postoperative discomfort for patients. The clinical application of low intensity laser in endodontic therapy has been considered useful in post pulpotomy, post pulpectomy, periapical surgery.

In addition, disinfection will be achieved in contaminated root canals due to the bactericidal effect of thermal interaction. Disinfection is a process that eliminates many or all pathogenic microorganisms, except bacterial spores. High intensity lasers such as Nd:YAG (Neodymium: Yttrium, Aluminum, Garnet), Er:YAG (Erbium: Yttrium, Aluminum, Garnet), Excimer, CO_2(Carbon dioxide) and diode have been recommended successfully as an adjuvant method in the endodontic treatment of contaminated canals to remove bacteria from the root dentinal surface as well as from deep dentinal layers, pulpotomies and pulpectomy.

Bleaching is a chemical whitening teeth in which hydrogen peroxide, sodium perborate, chlorine etc are used. In office bleaching techniques may involve use of energy sources to increase rate of release of bleaching radicals. Different lasers produce different wavelengths, hence not all lasers are suitable for bleaching. Wavelength absorbed, scattered or transmitted through tooth structure cannot be used for bleaching as it will damage enamel dentin and pulp. KTP, Argon and Diode lasers are used in office bleaching.

Lasers are also used in diagnosis, dental material curing, in orthodontics for bracket adhesion, tooth preparations etc. and has left no branch of dentistry untouched.

In past, dental treatment was quite troublesome for the patients, as patient was not aware about the necessity for treatment to be done as well as psychological factors such as fear of pain etc. Nowadays, with introduction of lasers, dental treatment have become easy and less painful. However, none of the laser guarantees total analgesia, but it has taken an important step in the direction to reduce pain.

Apart from this, safety measures regarding the use of laser should not be avoided. Prevention of accidents can be done by thorough knowledge of their causes and measures to avoid them.

Throughout the years, new types of devices have emerged, and new conceptions regarding their use on various types of tissues. A few of the practitioners are aware of this new technology, but others continue to plead for conventional instruments. In the past, dental treatment offered a lot of reasons for a patient to avoid the specialty services: not understanding the necessity of a treatment, psychological discomfort, economic and social factors; however, the fact that the greatest issue was the “fear of pain” was scarcely discussed. From the moment the first extraction was accomplished, fear of pain dominated dentistry, becoming the obsession of patients, as well as the major preoccupation of dentists. More than any other cause, the fear of pain has become the source of professional stress. In the future, with the emergence of laser, patients will enjoy a better oral health, and will have more procedures available for improving their physionomic aspect. None of the currently available lasers guarantees a total analgesia, but the present laser has taken an important step in this direction.

Application of laser radiation on soft tissues has constituted the first field of clinical use of laser in dentistry. In order to extend the applications in dentistry, researches should be based on the understanding of the effects of various wavelengths and other laser parameters on tissues. The laser of the future will probably be capable of producing a multitude of wavelengths and impulse durations, each specific for a certain application. When optimal parameters will be known, the ideal treatment will become a reality.

Scientific and medical researches, as well as the development of present systems, will define more and more clearly the field of use of laser radiation in dentistry, widening its therapeutic indications.

As it can be seen, there has been much progress in the area of lasers in dentistry since the early report by **Stern** and **Sognnaes**. These early researchers and those who followed wished to develop clinical uses for lasers with the aim of bringing the lasers to the dental practitioner to improve dental care. The progression has been slow, and some of the ambitions of the early researchers have yet to be realized.

When the knowledge of what parameters are necessary for ideal treatment is a reality, lasers can be developed that can provide dentists with the ability to care for patients with improved techniques and equipment.

In conclusion, the emergence of various types of lasers constitutes an important event, which will change completely the manner of understanding and practicing dentistry.

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