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**Research Paper**

# Diode Laser A Multifunctional Innovative Tool Shaping Future Of Modern Dentistry.

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***ABSTRACT**:*
*Facial expressions play a leading role in human interactions because they provide signaling information of emotion and create social perceptions of an individuals physical and personality traits.[15] "The prettiest smile are the once that show the most teeth" (DW Wilson). When we smile we attract people, but yellowishness of Teeth some time may also lead to psychological issues of low esteem, as the world is advancing rapidly in the field of science, engineering, technology & medicine. New researches are being done for further development & improvement in the medical science has come-up with new procedures & techniques for achieving desired results.*
*Due to present trends & exposure through social media there is a paradigm shift in aesthetic industry which have evolved based on the increase awareness of patient about the minimal invasive aesthetic procedures.[2] Many patients are interested in saving time and obtaining faster results, search for new laser device is being proposed, With development of laser technology. The purpose of this research paper is to update the Information on laser application field and give information about diode laser system with wavelength ranging from 810nm to 980nm Used for laser assisted bleaching,[12] thus use of LASER has been proved to be an effective tool to increase efficiency, specificity, ease, cost & comfort of Dental treatments.[3]*
***KEYWORDS:** Lasers, Diode Laser, Tooth Bleaching, Tooth Whitening.*

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## I. INTRODUCTION.

### 1.1- INTRODUCTION & HISTORY OF LASER.

The term LASER is an acronym for (Light Amplification by Stimulated Emission of Radiation) which was introduced to the public in 1959, in an article by a Columbia University graduate student, Gordon Gould.[2] Albert Einstein in 1917 [3] laid the foundation for invention of laser, in 1928-1932 he proposed the theory of laser but did not demonstrated it practically. In 1952 Twine & associates produced actual design of laser device and named it maser (microwave amplification by stimulated emission of radiation). LASER was tested for dental use between 1970-1980, LASER devices such as carbon diode (Co2) and neo dymium doped yttrium aluminum garnet [Nd:YAG] were considered suitable for use on hard tissues , in 1970 LASER were already in use for soft tissue procedures.[12]

Tooth discoloration is abnormal tooth color, hue or translucency. External discoloration is accumulation of stains on the tooth surface. Internal discoloration is due to absorption of pigment particles into tooth structure. Sometimes there are several different co-existent factors responsible for discoloration. There are several techniques available for the treatment of darkened teeth and bleaching is one of the least aggressive methods. The introduction of new materials, the variety of light sources and the appearance of different protocols have allowed greater effectiveness of the tooth bleaching to be sought, operational facility for the dentist and safety for the patient.[7]

Bleaching is a chemical process characterized by oxidative decomposition of bleaching agents to remove external stains from tooth surface to obtain lighter tooth color.[2] The terms "whitening" and "bleaching" are often used interchangeably, which can lead to confusion when interpreting the literature. According to the US Food and Drug Administration (FDA), whitening restores teeth to their natural tooth color, whereas bleaching makes teeth lighter than their natural color.[11] The FDA approved the use of Aragon, CO2 and diode laser for bleaching purposes. [1] Several methods have been proposed to evaluate tooth color changes following whitening procedures. Photo-spectrometry is Considered as a standard method of Color evaluation as its advantages include Lack of operator influence, reproducibility, Reliability In calibration and executing the

environmental light interference. This technique is universally standardized and software dependent in data recording and analyzing thereby minimizing personal evaluation bias.[10]

### 1.2- HISTORY OF LASER IN DENTISTRY.

Introduction of laser in dentistry dates back to the 1960s, by scientist working for The Hughes Aircraft Corporation, Theodore Miaman who proposed its mechanism based on emitted beam coming from ruby crystal.[12 The first description of professional bleaching of discolored 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 [11]. The teeth bleaching market is divided into two main groups: in- office bleaching and at-home bleaching. In-office bleaching offers the patient less exposure time to the bleaching agent, more acceptable results, and professional control over the treatment process to ensure its effectiveness. High concentration hydrogen peroxide (25% to 40%) and carbamide peroxide (35% to 38%) are usually the agents used in in-office bleaching. They are activated either by chemical means, or external energy sources such as blue colored halogen curing lamps, advanced LED light, or light amplification by stimulated emission of radiation "laser".[2]

### 1.3- METHODS OF LASER.

Laser light is a monochromatic light and consist of a Single wavelength of light. It consist of these principal parts that is an energy source, and active lasting Medium, Two or more mirrors that form an optical cavity or resonator for amplification to occur, energy is supplied to laser system by a pumping mechanism such as a flash lamp/device. An electrical current or an electrical coil this energy is pumped into an active medium content within an optical resonator, producing a spontaneous emission of photons subsequently amplification by stimulated emission takes place as the photos are reflected back and further through the medium by the highly reflective surface of the optical resonator prior to their exit from the cavity via other output couple are in dental laser, the laser light is delivered from the laser to the target tissue via fibre-optic cable hollow Wave guard & articulated as focusing lasers. The wavelength and properties of the laser are determined Primarily by the composition of an active medium, which can be gas, a crystal or a solid-state semiconductor.[3]

### 1.4- Difference between in-office bleaching using LASER & at home conventional bleaching.

| IN-OFFICE LASER BLEACHING. | AT HOME CONVENTIONAL BLEACHING. |
|---|---|
| In-office concentration of hydrogen peroxide ($H_20_2$) ranges from 25% - 40%. Carbamide peroxide 35% - 38%.[2]<br>The main advantage of an office bleaching technique include dentist control, avoidance of tissue exposure, reduced treatment time and enhance patient satisfaction due to immediate result [joiner 2006]<br>Power bleaching has been performed varying hydrogen peroxide activation techniques since 1910[7]<br>The American Dental Association encourages all patients interested in tooth bleaching to seek advice from a dental professional. [13] | At home concentration of hydrogen peroxide ($H_20_2$) ranges from 3% - 7.5%.<br>There has been an increase demand of whitening tooth home-based whitening procedures with a bleaching action which have become popular and are Purchased over the counter, a variety of whitening products are available which include hydrogen peroxide, carbamide peroxide, sodium carbonate, sodium hexameta phosphate, sodium tripoly phosphate & calcium peroxide. These agents are supplied in different concentrations and are used with different method of application (gel in tray, strips, paint or gel, drain gums and mouth wash) which have varying application time and duration of treatment.[7] |

### 1.5- Difference between LED & LASER systems.

| LED LIGHT | LASER DIODE |
|---|---|
| Light generated by spontaneous emission.<br>Carrier density in the active region not pinned, it keeps increasing with increasing input current.<br>LED's are neither coherent nor collimated.<br>Wide emission spectrum.<br>Polarization state random.<br>Total optical output power is medium.<br>LED system is not precise.<br>Works at slower speed then LASER.<br>Travels short distance.<br>Does not require a trained professional for application. | Light generated by stimulated emission.<br>Carrier density in active region is pinned beyond the threshold current.<br>LASER are monochromatic (single color wavelength) example- Diode laser- Red color. Diode laser are Collimated and coherent.<br>Narrowest emission spectrum.<br>Polarization state is linear.<br>Total optical output power is high.<br>Diode laser system provide the operator to perform precise work.<br>Works at high speed.<br>Can travel longer distance.<br>Require a trained professional for application. |

### 1.6- TYPES OF LASER

The most common Dental LASER in use today are erbium, Nd: YAG, Diode, chromium doped : yttrium, Scandium, gallium, garnet [Cr: YSGG] and Co2.[12]

- Nd: YAG LASER (1064nm)

  True pulse lasers with a near infrared wavelength of 1064nm are Marketed for Dental use procedures. The Nd:YAG laser can be used in Dentistry to remove soft tissue, disinfect canals in endodontic procedures and prevent caries.

- ERBIUM laser (2790nm)[3]
  The ERBIUM laser family in of lasers has two distinct wavelengths Er,Cr: YSGG (yttrium scandium gallium garnet) lasers. The Erbium Wavelength has high affinity for hydroxyapatite and the highest absorption of water, Consequently it is the laser of choice for treatment of dental hard tissues.
- $C0_2$ LASER (9600nm-10,600nm)
  Their main use are preparation, incision and remodeling of soft tissue such as incisional and excisional biopsy's, frenectomy, gingivectomy & prosthetic procedures & procedures which can also be done with excellent hemostasis, blocking of nerve endings and eliminating the need for sutures often offers the patients a comfortable post operative experience.
- Diode laser (810nm-980nm)[3]
  The active medium of the diode laser is a solid-state semiconductor made of aluminum Gilliam & Occasionally indium, which produce laser wavelengths ranging from approximately 810 nm two 980 nm all the diode laser are primarily absorbed by tissues pigment melanin and haemoglobin, but are poorly absorbed by hydroxyapatite and water present in the enamel. Specific procedures include aesthetic gingival re-countering , soft tissue crown lengthening, exposure to soft tissue impacted teeth, removal of inflamed and hypertropic tissue, frnectomies and Photo stimulation of Apthous and herpetic lesions. [3]

**Table:1 LASER used in Dentistry with their emission wavelengths & delivery systems.**

| LASER TYPE | LASING MATERIAL | WAVELENGTH (nm) | DELIVERY SYSTEM |
|---|---|---|---|
| **Argon** | Gas laser | 488/515 | Optical fibers |
| **KTP (green)** | Solid state | 532 | Optical fibers |
| **Helium neon (red)** | Gas laser | 633 | Optical fibers |
| **Diode (red)** | Semi-conductor | 635-980 | Optical fibers |
| **Nd: YAG (NIR)** | Solid state | 1064 | Optical fibers |
| **Ho: YAG (NIF)** | Solid state | 2140 | Optical fibers |
| **Er, Cr: YSGG (NIF)** | Solid state | 2790 | Optical fibers |
| **Er: YAG (NIR)** | Solid state | 2940 | Optical fibers, wave-guard, articulated arm. |
| **CO2 (FIR)** | Gas laser | 9600 or 10,600 | Wave-guard, articulated arm |

{NIR-near infrared, FIR- far infrared.}

## II. MECHANISM OF ACTION OF DIODE LASER.

The light energy produced by laser can have four different interactions with a target tissue Reflection, transmission, scattering and absorption when a laser is absorbed it Elevates the temperature and produces photochemical effect depending on the water content of the tissues. When a temperature of hundred degrees Celsius is reached vaporization of the water within the tissue occurs, a process called Ablation at temperature below hundred degrees Celsius but above approximately 60°C proteins begins to denature, without vaporization of underlying tissue conversely at temperature about 200°C the tissue is dehydrated and then burned, resulting in an undesirable effect called carbonization. Absorption requires an absorber of light,

Termed as chromophores, Which have a certain affinity for specific wavelength of light. The primary chromophore is the Intra oral soft tissue and melanin, hemoglobin and water, where as in dental hard tissue water and hydroxyapatite. Different laser wavelengths have different absorption coefficients with respect to their primary tissue components, making laser selection procedure dependent. [3]

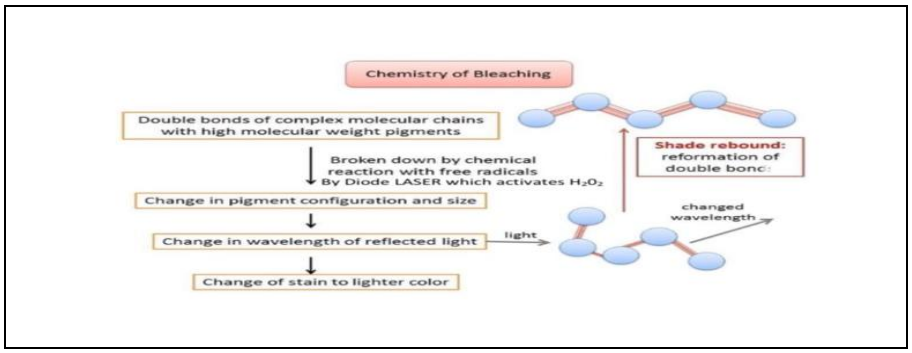
The role of laser in teeth whitening is to accelerate the activation of hydrogen peroxide ($H_2O_2$) in whitening gels which typically contain 30% to 35% $H_2O_2$ concentration. In reaction to the absorption of photon, the hydrogen peroxide breaks down into particle of water and radical of oxygen. The free radical oxygen chemically reduces larger organic-pigmented molecules (the chromophores) in the enamel matrix into smaller, less pigmented constituents by rapid oxidation. These compounds that originally have double bonds and long carbon chains are subsequently reduced to smaller carbon chains and hydroxyl groups, which eliminate discoloration. Before laser, several other lights such as Xenon Lamp, halogen light, plasma arc lamp light etc. was used to replace the role of light. But due to an inefficient light power output, limited effective lifetime and regular light consumed high electric power, researches kept trying to find new ways to accelerate the activation of H2 O2. These lights use a tiny percentage of the polychromatic light energy and the rest is wasted as heat and light which is absorbed by adjacent tissue. The properties of laser which include coherent, monochromatic and collimated can reduced the amount of light absorbed by adjacent tissue.[14]

**Laser wavelengths and tissue interaction-**

Characteristics of laser depend on its wavelength, Which affect both the clinical application and design of lasers. Laser selection is procedure dependent, As different laser wavelengths have different absorption coefficient with respect to primary tissue components. [4]

### 2.1- CHEMISTRY OF BLEACHING.

Double bonds of complex molecular chain with high molecular weight pigments are broken down through chemical reactions with free radicals using diode laser which speeds up the process by activation of $H_20_2$, as a consequence there is a considerable change in pigment configuration & size leads to a change in the wavelength of the reflected light and the change of the stain to a lighter color, in the best-case scenario it leads to elimination of discoloration of the tooth structure.




## III. APPLICATIONS OF DIODE LASER IN DENTISTRY.[12]

| SOFT TISSUE APPLICATION | HARD TISSUE APPLICATIONS | MISCELLANEOUS APPLICATIONS |
|---|---|---|
| • Lasers are successfully used for wound healing.<br>• Post herpetic neuralgia and apthous ulcer healing.<br>• Photodynamic therapy for malignancies.<br>• Aesthetic gingival re-contouring and crown lengthening.<br>• Removal of inflamed tissue.<br>• Exposure of unerupted and partially erupted teeth.<br>• Frenectomies. | • Enamel whitening.<br>• Restorative treatment.<br>• caries removal.<br>• cavity prepererations.<br>• Etching.<br>• dentinal hypersensitivity treatment.<br>• TMJ pain therapy and for diagnostic purposes. | • 3-D laser scanner for e-model preparation. |

## IV. IN-OFFICE PROCEDURE OF LASER TOOTH BLEACHING.

### 4.1- OPERATOR SAFETY PROTOCOLS.[4]

- Safety goggles for eye protection.
- Use of surgical hand gloves & foot wear should be worn by the operator.
- Use of mouth mask should be done to prevent airborne contamination, headcap & apron should be worn.

**PATIENTS SAFETY PROTOCOLS.**

- Safety goggles for eye protection & apron should be used.
- Gingival barrier should be placed correctly.

### 4.2- MATERIALS & METHOD.

Laser tooth whitening In-office, Image of the patient before the procedure is taken shade of the tooth is marked, diode laser with wavelength 810 nm 980 nm & hydrogen Peroxide 25%-40%, The patient pre-operative Is prepared by application of protective wear (goggles for eye protection & apron) bleaching retractor is placed and isolation of the teeth is done. saliva ejector, cotton roll & bleaching retractor are placed isolation of the tooth and protection of the gingiva is done by application of gingival barrier & curing it. Application of $H_2O_2$ 25%-40% is done followed by Diode laser 810nm - 980nm for activation of the bleaching gel. Removal of the applied gel & gingival barrier is done through rinsing and suctioning. Repetition of the procedure may be up to 2-3 times until desired shade change is achieved.

### 4.3- POST OPERATIVE PATIENT CARE.[9]

- Smoking should be avoided at least for 48 hours after the procedure.
- Aggressive tooth brushing should be avoided.
- Foods and beverages that stains the tooth should be avoided.

- In case of Mild sensitivity with to hot or cold liquids, it usually subsides within 1-2 days if not dentist should be consulted.
- Touch-up treatments are recommended every 6-12 months or as individual patient requirement.

Whitening of tooth does not last long & results will fade over time. Longevity & lasting of tooth whitening varies between each individual and depends on a number of factors, including: age, starting tooth shade, history of trauma to teeth, diet, oral hygiene, and smoking. Whitening results can be maintained with a touch up procedures once every 6 months. Whitening is most effective after having teeth professionally cleaned, and regular maintenance requires less work and less material.

**BEFORE & AFTER IMAGES DIODE LASER TOOTH BLEACHING.**


## V. INDICATIONS & CONTRA-INDICATIONS, ADVANTAGES & DIS-ADVANTAGES OF DIODE LASER TOOTH BLEACHING.

| INDICATIONS | CONTRA-INDICATIONS |
|---|---|
| Superficial enamel discoloration.<br>Mild yellow discoloration, brown fluorosis discoloration.<br>Age-related discoloration. Example- In Geriatric patients. | Sever enamel loss, Defective coronal restorations.<br>Hypersensitive teeth, presence of caries, Active peri-apical pathology.<br>Allergy to bleaching gel.<br>Local infection, blood diseases, photosensitivity or use of such drugs.<br>Lasers are Contraindicated in epileptic patients |

| ADVANTAGES OF DIODE LASER. | DISADVANTAGES OF DIODE LASER. |
|---|---|
| The main advantage of diode laser is its small size portability and flexibility.[1]<br>Laser tooth bleaching is effective, less time consuming.<br>Laser bleaching procedure can be completed with a single in-office treatment allows one to focus on a single tooth or even a selected part of tooth.<br>It was proposed that use of a high-intensity light in bleaching acts as an accelerator for bleaching agents by increasing its temperature does improving the effectiveness of the treatment.<br>Lasers were introduced to accelerate bleaching official effectiveness and efficiency by enhancing hydrogen peroxide oxidation effect, thus reducing patients chair time and increasing acceptance. [2]<br>Laser activated bleaching can be satisfactory for patients seeking good color stability with maintenance over time.<br>It is considered as most popular Non-invasive cosmetic treatment done to lighten tooth shade beyond its natural color.[2]<br>Laser sterilize the area as inclined temperature have profound effects on the structure & physiological properties of sporulating and non-sporulating bacteria, with membrane RNA, DNA. | The diode laser parameter for clinical application should be carefully assisted to prevent potential hazards and vitality.<br>Laser tooth whitening is more expensive than other tooth whitening options.<br>One of the concerns of bleaching is persistence of color change for an optimum period of time, additional adverse effect on enamel include porosities, change in microhardness & surface roughness of enamel. [2]<br>The presence of microscopic enamel porosities were found to be one reason that can cause color change.<br>The change in the surface topography & alternation in calcium phosphate ratio of the tooth structure will cause surface roughness & irregularities that will affect color stability of bleached tooth. The rough surface will be more susceptible to retain stains & color rebound will occur. [2]<br>Another concern is the post bleaching hyper sensitivity which is most prevalent drawback of in office bleaching technique.<br>All the stated theories Claim that hydrogen peroxide infiltrates the dental structure through surface porosities caused due to bleaching gel. |

## VI. MRDICO LEGAL CONSIDERATION

Most professional liability insurance policies are designed for dental specialist. [5] Hard and soft tissue procedure with dental laser is considered a covered procedure, prior informed consent must be considered and the patient must read and acknowledge with signature before any laser treatment.

## VII. DISCUSSION

The perception of colour and shade evaluation by human is under influence of environmental and physical variabilities. Diode laser is FDA approved laser for tooth bleaching process. several controversies exist on the effectiveness of bleaching agents associated with light sources some studies showed superior efficiency and effectiveness of power bleaching process with light. while other studies demonstrated that the bleaching efficacy is mainly related to chemical composition of bleaching material and not to the type of light source used.

The latest development of power bleaching is laser activated bleaching. Laser emits a well-defined light at a single wavelength only, which is claimed to be less harmful and more effective with short application In-office. The main effect of laser energy is photo thermal effect that converts light energy into heat and increase the rate of bleaching process. few investigations have been published analysing diode laser efficacy during tooth bleaching process. [1]

## VIII. CONCLUSION

Lasers have made tremendous improvements in the dental world by the 21st century. Laser-based technology holds greater promise in the coming future and thus emphasizes on a combination of diagnostic and therapeutic laser technique.[5] It has been concluded that under the conditions of this study, both LASER assisted & power bleaching or home bleaching were able to achieve color change & obtaining desired results,[7] The study showed positive effect of diode laser irradiation at 810-980nm wavelength on prevention of bleaching damage irrespective of the activation mechanism of bleaching gel in use,[6] they will contribute to most dental practices all around the world mainly due to its noninvasive approach. Significant contribution of lasers in the modern dental practice has served as an adjunctive to conventional mechanical procedures. [5] Several Controversies exist on effectiveness of bleaching agents associated with light source, Some studies showed superior effectiveness of power bleaching process with light. Diode laser is FDA approved laser for two bleaching process. The latest development of power bleaching is laser activated bleaching Which is claimed to be less harmful and more effective with short application In-office. diode laser can be considered as an effective treatment option for bleaching when use along with bleaching agents. The reduced timeframe required to achieve desired whitening results May lead to high patient compliance and satisfaction, however for the long-term studies have to be conducted to prove the efficacy of laser treatment in Bleaching.[8] since laser have proved to be a multifunctional asset in this advanced technological era.[5]

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