

## Lasers in Dental Implantology

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### Abstract

### Review Article

Lasers were introduced into the field of clinical dentistry in 1989 with the hope of overcoming some of the drawbacks posed by the conventional dental procedures. The two expanding aspects may be combined to provide the patients with a better clinical outcome. Since its first dental application, the use of laser has increased rapidly in the last couple of decades. Their use in implant dentistry has seen an upsurge in the past years. At present, wide varieties of procedures are carried out using lasers. Laser can be classified based on the wavelengths and tissue on which it acts. All available dental laser wavelengths cannot be used in every dental implant situation. The dentist must fully understand the characteristics, merits and demerits, and applicability of the available lasers. The aim of this article is to review the applications of lasers in implant dentistry.

**Keywords:** Dental implant, laser.

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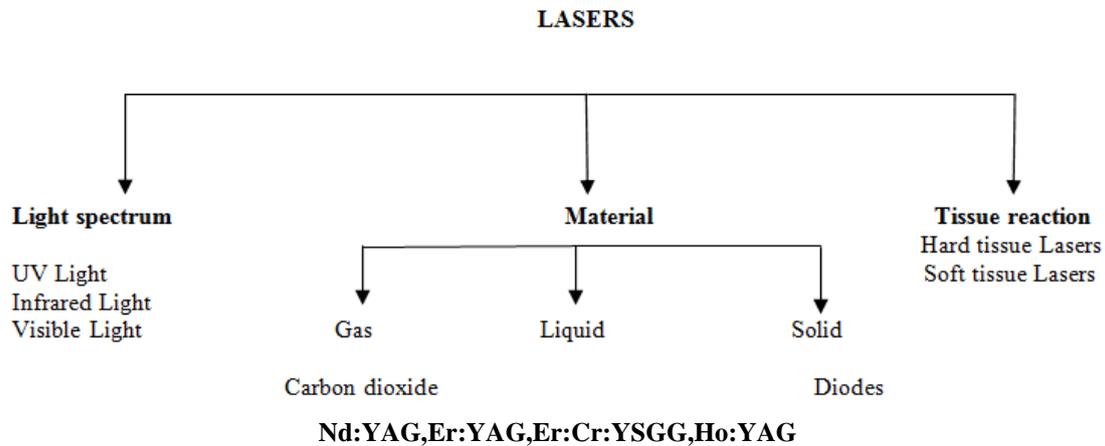
## INTRODUCTION

Laser is an acronym for ‘‘light amplification by stimulated emission of radiation named by Gordon Gould in 1957. Lasers have been used for performing a variety of procedures, both in the medical and dental fields since its introduction by Maiman in 1960 [1, 3]. Drs. William and Terry Myers used a modified ophthalmic Neodymium: Yttrium Aluminum Garnet (Nd: YAG) laser for dental use in 1989 [4]. The potential benefits derived from lasers depend largely upon the unique properties of laser energy at a particular wavelength and its interaction with dental tissues. The inherent properties of laser light such as selective absorption, coagulation, sterilization and stimulatory effects on vital structures offer some advantages over traditional techniques, making lasers the treatment of choice in certain situations. Unlike natural light which is composed of various electromagnetic fields travelling in disoriented fashion (incoherent), the light of laser beam is collimated (parallel) coherent (waves all in same phase) and monochromatic (single wavelength).

Lasers can be classified as soft tissue lasers and hard tissue lasers based on the tissue interaction. The soft tissue lasers include carbon dioxide (CO<sub>2</sub>),

Nd: YAG, diode, argon, and holmium wavelengths whereas Erbium: YAG (Er: YAG) and Er: Yttrium scandium-gallium-garnet (Er: YSGG) are hard tissue lasers. Their use can be either an adjunct to other procedures or the main form of treatment itself. The use of lasers in dentistry has grown in last 10-12 years with advent of soft-tissue diode lasers which are cost-effective, portable, and reliable. Lasers have many clinical applications in improving the pre-surgical, surgical, post-surgical, and prosthetic phases of modern implant dentistry. The part of lasers in implantology was explored by Romanos *et al.* and they concluded that soft-tissue lasers could be of benefit in implant dentistry [5]. Light is emitted via laser primarily through stimulated emission. It may get transmitted, reflected, scattered, or absorbed on reaching the surrounding tissues. This light along with its antibacterial abilities may be absorbed by implants and surrounding tissues. The advantage of using lasers in implant dentistry includes hemostasis, decreased swelling, minimal damage to soft tissues, diminished infection, and reduced pain postoperatively [4] current article discuss about various clinical implications of lasers in implantology.

**Classification of lasers**



**Characteristics of lasers used in implantology**  
**CO2 LASER**

CO2 laser was first time developed by Patel *et al.* in 1964.[6] CO2 laser have a wave length of 10.6 microns, are gas and fall into the far infra-red into the spectrum. All CO2 lasers works in non-contact mode. CO2 lasers have an affinity for wet tissues regardless of tissue colour. They are highly absorbed in oral mucosa, which is more than 90% water, although their penetration depth is only about 0.2 to 0.1mm. There is no scattering, reflection, or transmission in oral mucosa. Hence, what you see is what you get. CO2 lasers reflect off mirrors, allowing access to difficult areas. Unfortunately, they also reflect off dental instruments, making accidental reflection to non-target tissue a concern. As CO2 lasers are invisible, an aiming helium – neon (He Ne) beam must be used in conjunction with this laser. One of the limitation of this laser is the penetration depth is approximately 0.2 to 0.3 mm.

**Nd: YAG Laser**

Here a crystal of Yttrium – aluminum – garnet is doped with neodymium. Nd: YAG laser, has wavelength of 1,064 nm (0.106) placing it in the near infrared range of the magnetic spectrum. Nd: YAG laser was first developed by Geusic in 1964. A crystal of yttrium-aluminum- garnet doped with neodymium is used and they are invisible similar to CO2 laser, have infra-red range on spectrum. It is not well absorbed by water but is attracted to pigmented tissue. Eg: hemoglobin and melanin. Therefore various degrees of optical scattering and penetration to the tissue, minimal absorption and no reflection. Most dental Nd: YAG lasers work in a pulsed mode. At higher powers and pulsing, a super-heated gas called plasma can form on the tissue surface. It is the plasma that can be responsible for the effects of coagulation, vaporization or cutting. If not cooled (eg: by running a water stream down the fiber) the plasma can cause damage to the surrounding tissues.

**DIODE LASER: Indium-Gallium-Arsenide-Phosphide-Ingaasp (Diode); Gallium-Aluminum-Arsenide-Gaalas (Diode); Gallium-Arsenide - Gaas(Diode)**

It has wavelength range of 635 to 950 nm, utilizing flexible quartz fiber; it is absorbed by pigmentation of the soft tissue. Thereby making diode laser an excellent hemostatic agent. Diode is used for soft tissue removal in contact mode, giving tactile sensation similar to electro cautery. Tissue penetration is less than comparable Nd: YAG effects, with potential for heat damage to underlying bone reduction [7, 8]. The Nd:YAG beam is readily absorbed by amalgam, titanium and non-precious metals, requiring careful operation in the presence of these dental materials. The depth of penetration has been estimated to be 2 +\_ 1 mm in soft tissue.

**ERBIUM: YAG LASER**

In 1997 with FDA safety clearance erbium: YAG laser have been practiced on hard tissue like enamel, cementum, bone. Er: YAG laser has not been extensively used for the soft tissue applications. Helium neon laser is utilized as aiming beam in the fiber optic delivery system. Er: YAG laser has a wavelength of 2,940 nm, which is said to be ideal for absorption by hydroxyapatite crystals and water. This wavelength causes water to evaporate into steam, being irradiated resulting micro-explosion of the hard tissue [7]. Water spray is used to wet the surface during laser radiation to achieve maximum efficiency of tissue removal with minimum heat generation.

**Application of Lasers in Clinical Practice**

Use of lasers can be divided among four phases:

- Pre-surgical
- Surgical
- Post-surgical
- Prosthetic

**Pre-surgical****Preparation of surgical site**

This is the first step of implant surgery which includes disinfection of surgical site and degranulation of extraction sockets. Lasers have bactericidal effects and can cause sterilization of implant site. The erbium and diode lasers can accomplish decontamination and can remove granulation tissue from the extraction site. CO<sub>2</sub> lasers are non-contact lasers; therefore, it increases the spot size. The CO<sub>2</sub> lasers are also applicable in removing soft-tissue tags and decontaminating the bony surfaces [9, 10].

**Lateral window sinus lift**

CO<sub>2</sub> and erbium lasers can be used to create incision without compromising the bone integrity. In sinus lift procedure, graft material is placed between bone and Schneiderian membrane, so integrity of this membrane is necessary. Although piezoelectric devices have promising results, lasers can also be used if used with expertise [9].

**Surgical****Flap incision**

Dental lasers provide advantages of soft-tissue ablation, hemostasis and thus can also be used to make soft-tissue incisions. In comparison to surgical blade, it provides great hemostasis. Various lasers that can be employed for this purpose are diode lasers, CO<sub>2</sub> lasers, and erbium lasers difference being in their wavelength and depth of penetration. Wavelength offering water cooling mechanism reduces the thermal effects and keeps the visual field clean [10, 11].

**Osteotomy**

Erbium lasers can be used effectively in bone ablation as well, therefore, are effective in producing osteotomies [10, 12]. Use of drills causes anxiety and discomfort to patients, so lasers can be of advantage. The major advantage of using erbium lasers is during the preparation of initial guide hole as bur may slip over irregular bony surfaces [10]. Kesler *et al.* concluded that erbium lasers are safe option in osteotomy procedures. Decortication for guided bone regeneration – During placement of dental implants, implant site may require bone augmentation in either horizontal or vertical direction. Erbium family of lasers can be utilized for decortication of bone and research suggests that using laser is advantageous compared to bur [10, 15]. Kesler *et al.* showed that a higher level of platelet-derived growth factor is produced by erbium lasers compared to bur, and therefore, it enhances early healing [13, 14].

**Post-surgical**

After the placement of implant fixture, minute remodeling of hard and soft tissues can be performed by erbium lasers to assist in placement of ideal prosthetic components such as healing abutment [10]. Furthermore, the advent of low-level laser therapy

which provides increased biostimulation and bioinhibition can enhance faster bone formation and improves bone implant interface strength and osseointegration [16, 17].

**Uncovering implants**

Uncovering of dental implants in two stage surgery can be accomplished by various methods as described in the literature which includes traditional use of scalpel and later on electrosurgery both having their limitations, e.g., bleeding edge leading to post-operative sensitivity and delay in taking impressions and thermal effects due to electrosurgery. As an alternative to these, establishment of lasers in last decade has been useful [18, 19]. Using the laser for uncovering implants has advantages such as sterilization, depolarization of nerves, analgesia, and hemostasis [20]. Diode lasers and erbium lasers can best be used for this purpose. This can be accomplished either in a circular fashion or with a buccal roll technique depending on the presence of attached and keratinized tissue [19, 20]. Use of lasers can allow for taking impressions on the same day and also assists in abutment seating.

**Prosthetic phase**

Recontouring of soft tissues around implants may be required after surgery for prosthesis to fit in, for this all tissue erbium lasers, CO<sub>2</sub> lasers and diode lasers can be used. This can assist in both initial placements of final prosthesis and recementation [20].

**Use of Lasers in Treatment of Peri-implantitis**

Peri-implantitis is multifactorial in nature, which affects both hard and soft tissues around it. It can be managed in either surgical or nonsurgical manner. Non-surgical treatment includes the use of lasers to decontaminate the implant surfaces and then treating peri-implantitis. CO<sub>2</sub>, erbium, and diode lasers are used for this with erbium lasers having higher potential. Research shows that surgical treatment is better accomplished using erbium family of lasers as it can remove contaminated titanium layers from implant surface and shows most promising results [20–22].

**Non-surgical use of lasers****Laser-welded titanium framework technology**

Laser-welded technology has become a viable alternative to the conventional lost wax-casting technique in the field of implant dentistry. The properties of titanium offer many advantages for its use in bar superstructures, which when coupled with precision offered by laser energy allows for a much stronger, passively fitting superstructure [23, 24]. Literature is replete with scientific evidence establishing precision fit of titanium superstructures. Bergendal and Palmquist [25, 26] reported that titanium frameworks compared favorably with cast-alloy frameworks with no statistical significance in implant loss, framework fractures, component fit, or margin

bone loss. A 5-year study by Ortorp *et al.* [27] showed that success of laser-welded titanium frameworks parallels cast-alloy frameworks. Recently Jackson [28] reported favourable application of laser-welded titanium frameworks in treatment of three totally edentulous patients. However, he pointed out prosthetic veneer fracture from the superstructure as a possible complication, thus stressing on the need for a disciplined, predictable approach to the fabrication of such superstructures.

### Computer-aided laser cured surgical template

Presurgical planning is essential to obtain esthetic and functional implants, and a variety of techniques is presently available [29]. Surgically guided placement of implants is more accurate than freehand placement. Rapid prototyping techniques allow the production of physical models on the basis of virtual computational models. The rapid prototyping technologies that are currently in use are stereolithography (SLA), inkjet-based system (3 dimensional printing), selective laser sintering (SLS), and fused deposition modeling. SLA uses an ultraviolet laser to “laser cure” cross-sections of a liquid resin and is the technique which is commonly being used for the generation of computer-generated surgical guides [30-32]. SLS models are opaque, whereas SLA models are translucent [33]. Fabrication of surgical templates using SLA has been proved to benefit from high precision by several well-documented researches [34-39].

### Precautions Before and During Laser Surgery

Safety glasses are necessary for eye protection by all operatory personnel including the patient;

- Protection of patient’s throat and delicate oral tissues from accidental beam impact;
- Use of wet gauze packs or towels to avoid reflection from shiny metal surfaces;
- Adequate high speed evacuation should be used to capture laser plume, which is biohazard;
- Speed of movement of the laser beam over the target tissue in order not to occur thermal damage—exposure of bone to heating at levels equal to or more than 47°C is reported to include cellular damage leading to osseous resorption. Temperature levels of equal to or more than 60°C result in tissue necrosis [40]. Additionally, if soft tissue temperature increases above 200°C charring and carbonization occur [41].
- The clinician’s awareness of safety control measures and hazards and the recognition of existing standards of care are significant points for dental practitioners to avoid complications and failures [42].

### CONCLUSION

Lasers have become a ray of hope in dentistry. Lasers have made a tremendous impact on the delivery

of dental care and will continue to do so as the technology continues to improve and evolve. When used effectively and ethically, lasers are an exceptional modality of treatment for many clinical conditions that dentists treat on a daily basis. The results of implant procedures carried out with lasers seem to be promising only when correct laser with correct wavelength and power settings is used. Not only this, the clinician should have extensive knowledge of laser physics and laser tissue interactions before any laser treatment is carried out. Lasers have made a tremendous impact on the delivery of dental care and will continue to do so as the technology continues to improve and evolve. Lasers can prove to be a blessing in disguise if used safely and properly.

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