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REVIEW ARTICLE

Lasers in Prosthodontics—Part I: Implantology

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ABSTRACT

Lasers have revolutionized the dental treatment modalities and have become an inseparable part of advanced treatment options. The parallel expansion of implant dentistry and laser dentistry is quite apparent. As the laser energy is being put to use in various ways, prognosis of implant treatments is improving. This article aims to provide a comprehensive view of the use of lasers in implant dentistry including preoperative, postoperative and intraoperative clinical procedures.

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INTRODUCTION

With the advancement in the field of dentistry, the treatment modalities are becoming more precise and technology oriented day by day. Scientific researchers about the effect of the lasers on oral hard and soft tissues has made it viable to be utilized in the clinical practice. With technically advanced equipment used for the treatment, the outcomes are becoming more and more promising and equipment is made patient friendly. Lasers have revolutionized the dental treatment modalities and have become an inseparable part of advanced treatment options. It has utilization in a number of procedures related to removable and fixed prosthodontics and implantology. Introduction of lasers have made treatment simpler, reduced the complications and the procedures have become patient and clinician friendly without compromising on safety, effectivity and precision of treatment prognosis. The clinician must be familiar with the fundamentals of laser physics and tissue integration so that proper laser devices are used to obtain treatment objective safely and effectively.

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BASIC LASER PHYSICS

The word LASER is an acronym for light amplification by stimulated emission of radiation.

A laser consists of a lasing medium contained within an optical cavity, with an external energy source to maintain a population inversion so that stimulated emission of a specific wavelength can occur, producing a monochromatic, collimated, and coherent beam of light. The laser light photons produce a tissue effect, known in basic physics as work.

Laser light is monochromatic (one specific color; in dental applications that color may be visible or invisible). Laser light possesses three additional characteristics: collimation (beam having specific spatial boundaries), coherency (light waves produced in the instrument are all the same), and efficiency (clinically useful feature). Laser light provides the thermal energy with precision to do surgical procedures.

Amplification is part of a process that occurs inside the laser.

The term 'stimulated emission' has its basis in the quantum theory of physics, introduced in 1900 by the German Physicist Max. A quantum, the smallest unit of energy, is absorbed by the electrons of an atom or molecule, causing a brief excitation; then a quantum is released. This process is called spontaneous emission. Albert Einstein theorized that an additional quantum of energy traveling in the field of the excited atom that has the same excitation energy level would result in a release of two quanta, a phenomenon he termed stimulated emission. This process would occur just before the atom could undergo spontaneous emission. The energy is emitted, or radiated as two identical photons, traveling as a coherent wave.

Radiation refers to the light waves produced by the laser as a specific form of electromagnetic energy.

All available dental laser devices have emission wavelengths of approximately 0.5 lm (or 500 nm) to 10.6 lm (or 10,600 nm). They are therefore within the visible or the invisible infrared nonionizing portion of the electromagnetic spectrum and emit thermal radiation. The dental lasers have three types of emission modes, i.e. continuous wave, gated pulse and free running pulse or true pulse.

LASER ENERGY AND TISSUE TEMPERATURE

The principle effect of laser energy is photothermal (i.e. the conversion of light energy into heat). This thermal effect of laser energy on tissue depends on the degree of temperature rise and the corresponding reaction of the interstitial and intracellular water. As the laser energy is absorbed, heating occurs and the required result is achieved.

Target tissue effects in relation to temperature

Tissue temperature (C)	*Observed effect*
37-50	Hyperthermia
60-70	Coagulation, protein denaturation
70-80	Welding
100-150	Vaporization, ablation
>200	Carbonization

LASER WAVELENGTH USED IN DENTISTRY[1]

Each wavelength and each device has specific advantages and disadvantages. The clinician who understands these principles can take full advantage of the features of lasers and can provide safe and effective treatment.

Argon: Two emission wavelengths are used in dentistry: 488 and 514 nm. The 488 nm emission is the wavelength needed to activate camphorquinone, the most commonly used photoinitiator that causes polymerization of the resin in composite restorative materials. Some studies demonstrate increase in the strength of the laser-cured resin, when compared with resin cured with ordinary blue filtered light. It can also be used with other laboratory and chairside materials, such as light-activated whitening gels and impression materials. The 514 nm wavelength has its peak absorption in tissues containing hemoglobin, hemosiderin and melanin and has excellent hemostatic capabilities.

Diode (emission wavelength 800 nm): Diode lasers are relatively poorly absorbed by tooth structure so that soft-tissue surgery can be safely performed in close proximity to enamel, dentin and cementum. The diode is an excellent soft-tissue surgical laser and is indicated for cutting and coagulating gingival mucosa and for sulcular debridement.

Nd:YAG (emission wavelength 1064 nm): Common clinical applications are for cutting and coagulating of dental soft tissues and sulcular debridement, hemostasis, treatment of aphthous ulcers, or pulpal analgesia.

Holmium: YAG (emission wavelength 2100 nm) laser is used for arthroscopic surgery on the temporomandibular joint.

Erbium family (Erbium,chromium: YSGG has 2780 nm and Erbium: YAG has 2940 nm of emission wavelength): Clinical uses include caries removal, tooth preparation, osseous removal and tissue retraction for uncovering implants.

CO_2 laser (emission wavelength 10,600 nm) is used for surface modification and strengthening of tooth enamel for increased caries resistance.

Uses of laser in prosthodontics:[2] Recently inclination of clinicians to use dental lasers in the field of prosthodontics have been witnessed. Its various uses include the following:

Implantology

- Uncovering implants at second-stage surgery
- Peri-implantitis

Fixed Prosthetics/Cosmetics

- Crown lengthening/soft tissue management around abutments
- Osseous crown lengthening
- Troughing
- Formation of ovate pontic sites
- Altered passive eruption management
- Modification of soft tissue around laminates
- Bleaching

Removable Prosthetics

- Epulis fissuratum
- Denture stomatitis
- Residual ridge modification
  - Tuberosity reduction
  - Torus reduction
  - Soft-tissue modification

LASERS IN IMPLANTOLOGY

The parallel expansion of implant dentistry and laser dentistry in clinical practice is apparent. As advocates for laser dentistry continue to seek new ways to use the technology and as more practitioners become involved in implant dentistry, it is logical to see the concurrent use of both technologies in clinical practice.[3] As laser energy is being utilized in various ways in implantology, the treatment prognosis are improving. Following are few examples of how laser energy can be utilized in implant dentistry.

Role of Lasers in Ailing Implants

The sterilization of exposed implant surfaces with laser energy to rehabilitate ailing implants has been proposed.[4] Diode, CO_2 and Er:YAG lasers are used for the purpose of decontamination.[1]

Most titanium implants feature a rough surface to increase areas of implant-bone contact and anchorage force in alveolar bone. Surface roughness, however, makes elimination of bacteria from implants difficult. Several treatment regimens, like plastic curettes, metal curettes, ultrasonic scalers, bactericidal chemicals, such as chlorhexidine digluconate or iodine solutions, have been proposed for cleaning and decontamination of implant surfaces. Sterilization and cleaning of implant surfaces by means of lasers has been suggested.[5]

About the role of lasers in treating ailing implants, Deppe et al proposed that peri-implant defects can be treated successfully by laser decontamination without damaging the surrounding tissues in the dog model and can even lead to bone regeneration after CO_2 laser irradiation.[4]

Regarding the surface alterations in endosseous dental implants induced by irradiation, Kreisler et al recommended Nd:YAG and Ho:YAG lasers are not suitable for use in decontamination of implant surfaces, irrespective of the power output and with the Er:YAG and CO_2 laser, the power output must be limited so as to avoid surface damage. The GaAlAs laser seems to be safe as far as possible surface alterations are concerned. Study revealed that the clinical application of most common dental laser systems can induce implant surface alterations. Relevant factors are not only the laser system and power setting but also the application system.[5]

Role of Lasers in Peri-implantitis

Peri-implantitis is considered to be a multifactorial process involving bacterial contamination of the implant surface. It is an inflammatory process that affects the soft and hard tissues around the implant and involves bone loss. Development of the biofilm on the surface of the dental implants plays a very important role in the appearance of peri-implantitis. The treatments proposed for peri-implant disease are based on the evidence gained from the treatment of periodontitis; however, the surface of the implants facilitates adherence of the biofilm bacteria and complicates its elimination.[6]

The principal objective of the treatment of peri-implantitis is to reduce bacterial colonization of the surface of the implant, mechanically eliminate the bacterial microbiota, and introduce an ecology capable of suppressing the subgingival anaerobic flora.[6]

Both surgical and nonsurgical techniques have been developed to this effect. Conventional treatment involves a combined application of local and systemic antibiotics, and mechanical and chemical cleaning of the damaged implant's surface with citric acid and tetracycline solution.[7]

For nonsurgical techniques, in general terms, the treatment of peri-implantitis in the case of incipient bone loss involves the elimination of plaque and tartar, with chemical plaque control in the form of 0.12% chlorhexidine rinses every 8 to 12 hours for 15 days, instructions on oral hygiene, decontamination of the prosthetic abutments, antibiotic treatment, and verification that the design of the prosthesis is adequate.[6]

Now days, lasers are used to sterilize the peri-implant tissue and implant surfaces and hence treat peri-implantitis. The antimicrobial activity of laser light, depends on its photodynamic therapy of laser energy.[8]

Early investigations into the effects of Nd:YAG laser photonic energy on a range of pathogens showed significant results, but in the early 1990s two studies concluded that the thermal effects of an Nd:YAG laser resulted in damage to the titanium surface. The effects of such thermal rise may be seen in site defects (pitting, melting craters), and local conductive effects into the bone. Furthermore a study using a CO_2 laser showed possible distant transportation of metal substrates to organs, such as the liver, spleen, and kidney. A comparative *in vitro* study undertaken by Kreisler of most commercially available laser wavelengths used without water cooling concluded that Nd:YAG and Ho:YAG lasers should not be used irrespective of the power output; CO_2 and Er: YAG laser should be used at low powers; and only the 809 nm diode group appeared to not cause any surface alterations. Kreisler also showed the high bactericidal potential of the Er:YAG laser on the implant surface.[9]

Comparison between the different methods of laser treatment additionally revealed a significantly greater effect of the Er:YAG over the diode laser.[8] Er:YAG is one of the most suitable wavelengths for bone applications. The 2940 nm wavelength is highly absorbed in the water component of dental tissue, and provides efficient ablation without the risk of significant thermal damage.[7] A study demonstrated that the Er:YAG laser at approximately 1 W (which is 'low' power) with a water spray could effectively remove plaque and calculus from the implant surface without damage.[9]

Discussing the laser effect on peri-implantitis *in vivo*, Dörtbudak et al advised the application of TBO and laser resulted in a significant reduction of the initial values of bacteria. Complete elimination of bacteria was not achieved.[10]

Most recently, an erbium,chromium-doped:yttrium, scandium,gallium and garnet (Er,Cr:YSGG) laser with a wavelength of 2.780 nm, which is more highly absorbed by OH-ions than water molecules, has been introduced to improve hard-tissue ablation. A commercially available Er,Cr:YSGG device using an ablative hydrokinetic process improves the performance for the removal of bacterial concomitants from implant surface. Laser ablation using Er,Cr:YSGG laser is highly efficient in removing potential concomitants on roughened implant surfaces while demonstrating no thermal effects.[11]

Role of Lasers in Uncovering Implants at Second Stage Surgery

Dental lasers have gained some popularity in peri-implant soft-tissue procedures involving exposure of implant cover screws (stage II surgery) or contouring hyperplastic gingiva.[5]

The CO_2 laser has also been recommended for applications in implant dentistry, which include uncovering implants at second-stage surgery and decontamination of exposed implant surfaces.[4]

Nd:YAG is used for soft-tissue second-stage surgery. The issue of concern is the transmission of heat to the bone from the heated implant surface, effects of this wavelength on the metal surface, the potential for pitting and melting, and the porosity of the implant surface.[1]

CO_2 laser energy, on the other hand, is reflected away and not absorbed on metal surfaces, which is a major advantage. The hemostatic properties of CO_2 are excellent, which is a tremendous advantage for its use on soft tissue. For osseous procedures, however, the CO_2 laser is not the instrument of choice because it has the potential to cause thermal changes to bone.[1]

The Erbium lasers do not have as significant a hemostatic capability as CO_2 or Nd:YAG. By using the erbium: yttrium,aluminum-garnet (Er:YAG) laser with small diameter tips and pulse repetitions of 8 to 10 Hz without water spray, it is possible to perform mucosal ablation without bleeding. Dry ablation with Er:YAG lasers produces more precise cuts in the oral mucosa.[1]

Role of Laser Microtextured Collars upon Bone Levels of Dental Implants

A goal of implantology research is to design devices that induce controlled, guided, and rapid integration into surrounding tissues. Events leading to integration of an implant, and ultimately to success or failure of the device, take place largely at the tissue-implant interface. Development of this interface is complex and involves numerous factors. These include not only implant-related factors, such as material, shape, topography, and surface chemistry, but also mechanical loading, surgical technique, and patient variables, such as bone quantity and quality.[12] Nowadays, microtexturing of the implants with lasers is being done to improve and maintain the integration at the tissue-implant interface. About the role of lasers microtextured collars, Weiner S et al proposed that microtexturing help to maintain the bone by controlling cell attachment, proliferation and differentiation.[13]

Role of Laser in Welding of Frameworks

In dentistry nowadays, laser welding is being increasingly used as a substitute metal connecting method because of a host of advantages it wields over conventional metal soldering. It relies on the conversion of light energy into thermal energy when laser is applied to a metal surface. Laser welding is easy to perform because it can be done directly on the working cast. It also offers excellent corrosion resistance and mechanical strength. In addition, since laser energy can be concentrated in a very small area, there are fewer effects of heating on the area surrounding the spot to be welded. This means that it is possible to repair a metal plate denture without removing the acrylic resin base or artificial teeth.[14]

However, laser welding is not without flaws and it poses a few problems. During laser welding, it is easy to generate welding defects, such as cracks and increased porosity at the joints of metal frameworks, which reduce the strength and durability of joints.[14]

It has been proposed that one of the ways to obtain a true passive fit for implant prostheses is by the elimination of the casting technique. The expansion and contraction during casting can lead to a nonpassive fit of the implant prosthesis when placed onto multiple implants. Laser-welded frameworks are a viable alternative to casting techniques. The proposed laser welding of titanium components has been advocated and used with some mixed success.

With laser welding in various types of joints, Michio et al recommended that specimens with a beveled edge yielded less deformation than specimens with a square edge and a double laser pulse waveform, whereby a supplementary laser pulse was delivered immediately after the main pulse-resulted in a smaller deformation than with a single laser pulse waveform.[14]

Role of Lasers in Mini-implant Placement

Using the autoadvance technique advocated by Balkin et al, a small opening could be placed into the soft tissue and approximately 3 mm into the bone. These mini-implants, 1.8 mm in diameter with a self-tapping thread, can be rotated slowly and autoadvanced into the soft cancellous bone. There is the potential benefit of the laser sterilizing the bone as it penetrates and creates an osteotomy site. It has been proposed by some clinicians who use lasers that it is possible to create the entire osteotomy site for conventional-sized implants.[1]

ADVANTAGES OF USING LASERS IN IMPLANTOLOGY

To summarize, the various advantages of the use of laser in implantology include the following:
- Increased hemostasis
- Minimal damage to the surrounding tissue
- Reduced swelling

- Reduced infection
- Reduced pain postoperatively
- Hard-tissue ablation, osteotomy preparation
- Decontamination of infected and ailing implant bodies
- Due to the hemostasis provided by lasers, there is the significant advantage of improved visibility during surgery.
- Another advantage of the use of lasers in implantology is that impressions can be taken immediately after second-stage surgery because there is little blood contamination and minimal tissue shrinkage in the field.
- A patient with potential bleeding problems could be treated with a laser to provide essentially bloodless surgery in the bone.

With all the advantages, there also is the potential for obliteration of the attached gingiva if this technology is overused.

Every equipment/technology has its own advantages and disadvantages. It is in the hands of the dentist to understand the clinical situation and implement what is best for the treatment objective. Thorough knowledge about the laser physics, wavelengths, equipment and procedure can only result in the desired treatment result.

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