

Laser and its Application in Prosthetic Dentistry

Shaista Durrani

Post graduate student, The Oxford dental college and Hospital, Milestones, Bommanahalli, Hosur Road, Bangalore, India.

Correspondence to:
Dr. Shaista Durrani, #F1, Rubi Apartment, Pearl City layout, Muttanellur, Sarjapur, Anekal, Bangalore-560099

ABSTRACT

Application of laser dentistry now days involve the routine use of various procedures once thought only possible with the conventional dental drill or scalpel. The introduction of the lasers to the specialties of dentistry like prosthodontics, surgery, periodontics and endodontics has brought a revolution in the treatment delivery with increased precision of procedures and comfort for the patients. Early use of lasers was limited only to soft tissue procedures and was considered superior to the conventional scalpel surgeries. With the introduction of newer wavelengths and improvement of existing ones, use of lasers has extended to hard tissue procedures. This led to the use of the novel technology for various clinical situations and laboratory procedures. At this juncture, it becomes imperative for general dental practitioners and specialists to possess complete knowledge about the different laser systems, their usefulness and risks associated with the use of the technology today. This article describes the different methods of application of laser technology for treatment of fixed and removable prosthesis, implantology and its advantages, disadvantages, safety and applications in dental laboratory for further investigatory purpose. The PubMed, Ebsco, Ermed, Doac and Google search engines were used to gather the articles.

KEYWORDS: Laser system, Technological innovation, precision of procedure, quality of treatment, associated risk

INTRODUCTION

The introduction of lasers in the field of prosthodontics has replaced many ordinary surgical and technical methods and has offered many sophisticated products designed to improve the quality of treatment rendered to a patient. These procedures include hard and soft tissues tuberoses reduction, torus removal treatment of unsuitable residual ridges including undercut and irregularity desorbed ridges, treatment of unsupported soft tissues and other hard and soft tissues abnormalities. Stability, retention, function and esthetics of removal prostheses may be enhanced by proper laser manipulation of the soft tissues and underlying osseous structure.¹ Since the advent of laser application in dentistry, various cultivated products sketched to enhance the quality of treatment are being given to the patient. Hence, laser has begun to reform the field of dentistry. Laser is the acronym for "Light amplification by stimulated emission of radiation" termed by GORDO GOULD in 1957.² The first laser was introduced into the field of medicine and dentistry during the 1960s. Since then, this science has moved rapidly. Because of their many advantages, lasers are utilised for a wide variety of treatments.

MECHANISM OF DENTAL LASERS

A laser is a device that changes electrical or chemical energy into a very fine, intense beam of light energy that

alters light of several frequencies into an intense, small, and nearly non-divergent beam of monochromatic radiation, within the visible range.³

Laser Light - Laser light used for dental procedures is a form of electromagnetic energy that has four characteristic features – monochromatic (laser light is of one specific colour/ single wavelength unlike ordinary white light which is a sum of many colours of the visible spectrum), collimation (refers to the beam having specific spatial boundaries which ensure a constant size and shape of the beam emitted from the laser cavity). Coherency (means that the light waves created in the instrument are in phase with one another and have similar wave shapes, i.e. all the peaks and valleys are equivalent), and efficiency (at very low average power levels lasers can produce the required energy to perform their specific function, e.g. 2 watts of Nd: YAG laser light provides the thermal energy to precisely incise a gingival papilla).

Amplification - Amplification is part of a process that occurs in the laser. Lasers are generically named for the material of the active medium, which can be a container of gas, a crystal, or a solid-state semi-conductor. The electromagnetic energy is generated by excitation of an active medium like argon, CO₂, yttrium, aluminium, gallium, neodymium, or erbium that supply source of energy. It is raised by two mirrors which are placed parallel at each end of the optical cavity and emerges as laser light.

How to cite this article:

Durrani S. Laser and its Application in Prosthetic Dentistry. Int J Dent Med Res 2015;1(6):183-188.

Stimulated Emission - The smallest unit of energy, is occupied by the electrons of an atom or molecule, creating a short excitation; then a quantum is liberated, a process called spontaneous emission. The mirrors at each end of the active medium return the photons back and forth to permit the emission of the laser beam.

Radiation - Radiation refers to the light waves manufactured by the laser as a particular form of electromagnetic energy.^{3,4} The very short wavelengths below approximately 300 nm are called ionizing. In summary, a laser consists of a lasing medium contained within an optical cavity, with an external energy source to keep a population converse so that encouraged emission of a particular wavelength can occur, creating a monochromatic, collimated, and coherent beam of light.^{5,6}

CLASSIFICATION OF LASERS

Lasers used in dental practice can be arranged by several methods: According to the lasing medium, such as gas laser and solid laser; according to tissue applicability and tissue penetration, hard tissue and soft tissue lasers; according to the range of wavelength, according to the risk related with laser application and also according to potential hazards.

Types of Laser

Traditionally, laser have been classified according to the physical construction of the laser (e.g. gas, liquid and solid state), the type of medium which sustain lasing. Several types of lasers are available based on the wavelengths for use in dental treatment: 1) The Er:YAG laser possesses the potential of replacing the drill. 2) The Co2 laser can be used to perform gingivectomy and to remove small tumours. 3) Argon laser is used in minor surgery. 4) Nd:YAG is used for tissue retraction, endodontics, and oral surgery. 5) The diode laser is effective for oral surgery and endodontic treatment. This laser helps to correct esthetics flaws. It is also used for soft tissue methods.

Erbium laser: The erbium 'family' of laser has two wavelengths, Er, Cr: YSGG (yttrium scandium gallium garnet) lasers and Er: YAG (yttrium aluminium garnet) lasers. Erbium, chromium: YSGG (2780 nm) has an active medium of a solid crystal of yttrium scandium gallium garnet that is doped with erbium and chromium. Erbium: YAG (2940 nm) has an active medium of a solid crystal of yttrium aluminium garnet that is doped with erbium.⁷ The erbium wavelengths have a high empathy for hydroxyapatite and the highest absorption of water in any dental laser wavelengths. Therefore, the laser of choice for treatment of dental hard tissues.⁸ In addition to hard tissue methods, erbium lasers can be used for soft tissue ablation because the dental soft tissue carry a high percentage of water.⁹

Carbon Dioxide laser: The CO2 laser is a gas-active medium laser that includes a sealed tube holding a gaseous mixture with CO2 molecules raised via electrical discharge current. The light energy, whose wavelength is 10,600 nm, is placed at the end of the mid-infrared

invisible nonionizing portion of the spectrum, and it is delivered through a hollow tube-like waveguide in continuous or gated pulsed mode.¹⁰ The CO2 laser wavelength has a very high empathy for water, occurring in rapid soft tissue removal and hemostasis with a shallow depth of penetration. Although, it has highest¹¹ absorbance of any laser, disadvantages of the CO2 laser has large size and high cost and hard tissue injurious interactions.

Argon: Argon is laser with an active medium of argon gas that is energized by a high-current electrical discharge. It is fiber optically delivered in continuous wave and gated pulsed modes and is the only available surgical laser device whose light is radiated in the visible spectrum. There are two emission wavelengths used in dentistry: 488 nm, which is blue in colour, and 514 nm, which is blue-green.¹²

Neodymium Yttrium Aluminium Garnet Laser: Nd: YAG has a solid active medium, which is a garnet crystal combined with rare earth elements yttrium and aluminium, doped with neodymium ions. This active medium is much different than the semiconductor wafer of the diode laser, and the pumping mechanism is a flash lamp.³ The Nd: YAG wavelength is highly absorbed by the pigmented tissue, which make a very beneficial surgical laser for cutting and coagulating dental soft tissues, with good hemostasis. The available dental models have an emission wavelength of 1064 nm, which is in the invisible near-infrared portion of the electromagnetic spectrum. In addition to its surgical applications.¹³ There has been assessing for using the Nd: YAG laser for non-surgical cellular debridement in periodontal disease and the Laser Assisted New Attachment Procedure (LANAP).^{14,15}

Diode: The Diode is a solid active medium laser, manufactured from semi-conductor crystals using some combination of aluminium or indium, gallium, and arsenic. This "chip" of material has optical resonator mirrors joined to its ends, and an electrical current is used for pumping mechanism.¹⁶

The available wavelengths for dental use range from about 800nm for the active medium containing aluminium to 980 nm for the active medium composed of indium which is putting them at the starting of the near infrared portion of the invisible nonionizing spectrum. Each machine delivers laser energy fiber optically in continuous wave and gated pulsed modes and used in contact with soft tissue for surgery or out of contact for deeper coagulation. Classification according to the laser medium and wavelength are shown in Table I.⁵

APPLICATIONS OF LASERS IN PROSTHETIC DENTISTRY

1. Fixed prosthesis/esthetics

A. Crown lengthening: Clinical scenarios where crown lengthening methods are specified within esthetic zone, need attention to attain esthetic results. Crown

lengthening methods with the help of lasers are included in following situation:

- Caries at gingival margin
- Cuspal fracture extending apically to the gingival margin
- Endodontic perforations near the alveolar crest.
- Insufficient clinical crown length.
- Difficulty in a placement of finish line coronal to the biological width.
- Need to develop a ferrule.
- Unaesthetic gingival architecture.
- Cosmetic enhancements.

Lasers offer unparalleled accuracy and operator control and may be helpful for finely tracing incision lines and shaping the desired gingival margin outline. All the other crown lengthening methods has disadvantages in surgical approach healing time is longer, post healing gingival margin position is doubtful and patient compliance is poor as it needs use of anesthesia and scalpel for electro-surgery, the heat liberated has effect on pulp and bone leading to pulp death or bone necrosis.¹⁷

B. Soft tissue management around abutments: Argon laser energy has peak absorption in hemoglobin, thus, providing excellent hemostasis and well regulated coagulation and vaporization of oral tissues. These characteristics are beneficial for retraction and hemostasis of the gingival tissue in preparation for an impression during a crown and bridge method. Argon laser with 300 um fiber, and a power setting of 1.0W, continuous wave delivery, and the fiber is placed into the sulcus in contact with the tissue. In a sweeping motion, the fiber is moved around the tooth. It is dominant to contact the fiber tip with the bleeding vessels. Provide suction and water spray in the field. Gingivoplasty may also be done using argon laser.

C. Modification of soft tissue around laminates: The removal and re-contouring of gingival tissues cover can be easily efficient with the argon laser. The laser can be used as a primary surgical instrument to detach excessive gingival tissue, whether diseased, secondary to drug therapy or orthodontic treatment. The laser will detach tissue and supply hemostasis and tissues join the wound.

D. Osseous crown lengthening: Like teeth mineralized matrix of bone contains mainly of hydroxyapatite. The water content and hydroxyapatite produce for the high absorption of the Er: YAG laser light in the bone. Er: YAG laser has potential for bone ablation.

E. Formation of ovate pontic sites: There are many causes of the inappropriate pontic site. Two of the most common causes are inadequate compression of alveolar plates after an extraction and non-replacement of a fractured alveolar plate. Inappropriate pontic site results in unesthetic and non-self-cleansing pontic design. For favorable pontic design re-contouring of soft and bony tissue may be required. Soft tissue surgery may achieved with the soft tissue lasers and osseous surgery may achieved with erbium family of lasers. The use of an

ovate pontic receptor site is of great value when trying to produce a natural maxillary anterior fixed bridge. This is easily good with the use of a laser.

F. Altered passive eruption management: Lasers can be easily to control passive eruption problems. When the patients have clinical crowns that appear too short or when they have a jagged gingival line creating an uneven smile, excessive tissue can be detached without the need for blade incisions, flap reflection, or suturing.¹⁸

G. Laser troughing: Lasers can be used to produce a groove around a tooth before impression taking. This can be restored the require for retraction cord, electrocautery, and the use of hemostatic agents. The results are obvious, well regulated, minimize impingement of epithelial attachment, cause less bleeding during the impression, decrease postoperative problems and chair time.⁴ It changes the biological width of the gingiva. After laser grooving, the impression is taken and sent to the lab for prosthetic work. The main function of the marginal finish line is to keep the biological width, it acts as the termination point of tooth preparation, help in ease of fabrication, helps in taking a proper impression. In brittle teeth to keep the biological width and finish line laser grooving plays a main role.¹⁹

H. Bleaching: Esthetics and smile are main situation in our modern society. Bleaching of teeth can be achieved in the Dental OPD. Diode lasers are used to bleach teeth without causing much tooth sensitivity and modification of the complexion of the tooth.

I. Removal of veneer: Restoration can be removed without cutting with the help of laser beams. The laser energy passes through porcelain glass unchanged and is occupied by the water molecules present in the adhesive. Debonding takes place at the junction of the silane and the resin without causing any trauma to the underlying tooth.

J. Crown fractures at the gingival margins: Er: YAG or Er, Cr: YSGG lasers can be moved out to permit correct exposure of the fracture margin.²⁰

2. Implantology

Dental lasers are used for methods in implantology such as implant recovery, implant site preparation and detach of diseased tissue around the implant.

A. Implant recovery: Thus, the placement of implant and its combination into the osseous substrate, the method of treatment is surgically expose the implant, wait for the tissue to heal and start with impressions and fabrication of the restoration. Uses of lasers can proceed this method because the implant can be exposed, and impressions can be obtained at the same appointment. All types of lasers can be used to release dental implants. There is minimal tissue shrinkage after laser surgery, which tell that the tissue margins will continue at the same level after healing.^{21,22} In addition, the use of laser can detach the trauma to the tissues of flap reflection and suture placement.

B. Implant site preparation: Lasers can be used for the placement of mini implants generally in patients with potential bleeding problems, to give bloodless surgery in the bone.

C. Removal of diseased tissue around the implant: Lasers can be used to restore implants by sterilizing their surfaces with laser energy. Diode, CO₂ & Er: YAG lasers can be used for this reason. Lasers can be used to remove granulation tissue in case there is inflammation around an Osseointegrated implant.^{22, 23}

3. Removable prosthetics

The creation of removable full and partial dentures depend on the preoperative analysis of the supporting hard and soft tissue structures and their proper preparation¹⁸. Lasers may now be used to perform most pre-prosthetic surgeries. These methods involve hard and soft tissue tuberosity reduction, torus removal, and treatment of inappropriate residual ridges involving undercut and irregularly resorbed ridges, treatment of unsupported soft tissues, and hard and soft tissue malformation. Lasers may be used to treat the problem of hyperplastic tissue and nicotinic stomatitis under the palate of a full or partial denture and ease the irritation of epulis, denture stomatitis, and other problems related with long term wear of ill-fitting dentures. Stability, retention, function, and esthetics of removable prostheses may be increased by proper laser manipulation of the soft tissues and underlying osseous structure.

A. Treatment of unsuitable alveolar ridges: Alveolar resorption is uniform in vertical and lateral dimensions. Thus, irregular resorption occurs in one of the dimensions, making an inappropriate ridge. As the available denture, bearing area is decreased, the load on the remaining tissue increases, which leads to an ill-fitting prosthesis, with irritation. To detach sharp bony projections and to smooth the residual ridge soft tissue lasers surgery to uncover the bone may be produced with any number of soft tissue wavelengths (CO₂, diode, Nd:YAG,) Hard tissue surgery may be produced with the erbium family of wavelengths

B. Treatment of undercut alveolar ridges: There are many reasons of undercut alveolar ridges. Two of the most common reasons are dilated tooth sockets that result from inadequate compression of the alveolar plates after an extraction and non-replacement of a fractured alveolar plate. Naturally, occurring undercuts such as those found in the lower anterior alveolus or where a prominent pre-maxilla is present may be a reason of soft tissue trauma, ulceration, and pain when prosthesis is moved on such a ridge. Soft tissue surgery may be produced with any of the soft tissue lasers. Osseous surgery may be produced with the erbium family of lasers. Common surgery includes of detaching wedges of soft tissue from the alveolar crest until the wound edges are closed. Any of the soft tissue lasers are able to produce this method.^{24, 25}

C. Treatment of enlarged tuberosity: The most common cause for enlarged tuberosity usually is soft tissue hyperplasia and alveolar hyperplasia lead the over-

Laser Type		Wavelength	Colour
Eximer lasers	Argon fluoride	193 nm	Ultraviolet
	Xenon chloride	308 nm	Ultraviolet
Gas Lasers	Argon	488 nm	Blue
		514nm	Blue-Green
	Helium Neon	637 nm	Red
	Carbon dioxide	20600 nm	Infrared
Diode Laser	InGaAsP	655nm	Red
	GaAlAs	670-830nm	Red Infra Red
	GaAs	840nm	Infra Red
	InGaAs	980nm	Infra Red
Solid State Laser	Frequency doubled Alexandrite	337nm	Ultraviolet
	Potassium Titanyl Phosphate	532nm	Green
	Neodymium: YAG	1064nm	Infrared
	Holmium:YAG	2100nm	Infrared
	Erbium,Chromium:YS GG	2780nm	Infrared
		2790nm	Infrared
	Erbium:YSGG	2940	Infrared
	Erbium:YAG		Infrared

Table I: CLASSIFICATION ACCORDING TO THE LASING MEDIUM⁵

Laser Type	Current/Potential dental application
Eximer Lasers Argon Fluoride (ArF) Xenon Chloride (XeCl)	Hard Tissue ablation, Dental Calculus removal
Gas Lasers Argon (Ar)	Curing of composite materials Tooth whitening, Intraoral soft tissue surgery, Sulcular debridement
Helium Neon (HeNe)	Analgesia, Treatment of dentin hypersensitivity, Aphthous ulcer treatment
Carbon dioxide (CO₂)	Intraoral and Implant soft tissue surgery, aphthous Ulcer treatment, removal of gingival melanin pigmentation, treatment of dentine hypersensitivity, analgesia
Diode-lasers Indium gallium arsenide Phosphorous (InGaAsP)	Caries detection
GaliumAluminium Arsenide (GaAlAs)	Intra oral general and implant soft tissue surgery, sulcular debridement, Galium arsenide (GaAs) (subgingival curettage in periodontitis and periimplantitis) Analgesia, Treatment of dentine hypersensitivity, pulpotomy, Root canal disinfection
Solid State Lasers Frequency doubled calculus Alexandrite	Selective ablation of dental plaque
Neodymium : YAG (Nd:YAG)	Intraoral soft tissue surgery, sulcular debridement, Analgesia, Treatment Of Dentine hypersensitivity, Pulpotomy
Erbium Group Erbium:YAG	Caries removal & cavity preparation Modification of enamel & dentine surfaces, Uncovering of implants, soft tissue surgery, Treatment of dentine

Erbium:YSGG	hypersensitivity
Erbium,chromium :YSGG	

TABLE II: CURRENT AND POTENTIAL APPLICATION OF LASERS²⁷

eruption of unopposed maxillary molar teeth. The expand tuberosity may stop the posterior extension of the upper and lower dentures, thereby, decreasing their planning for mastication and their strength. The bulk of the hyperplastic tuberosity may rest toward the palate. The soft tissue decrease may be accomplished with any of the soft tissue lasers.

D. Surgical treatment of tori and exostoses: Prosthetic problems may arise if maxillary tori or exostoses are large or irregular in shape. Tori and exostoses are formed mainly of compact bone. They may cause ulceration of oral mucosa. These bony protuberances also may interfere with lingual bars or flanges of mandibular prostheses. Soft tissue lasers may be use to expose the exostoses and erbium lasers may be use for the osseous reduction.²⁶

E. Soft tissue lesions: Persistent trauma from a sharp denture flange or over compression of the posterior dam area may produce a fibrous tissue response. Hyper plastic fibrous tissue may be formed at the junction of the hard and soft palate as a reaction to constant trauma and irritation from the posterior dam area of the denture. The lesion may be excised with any of the soft tissue lasers and the tissue allowed re-epithelialized.

Current and potential application of lasers in dentistry are shown in Table II.²⁷

LASERS IN MAXILLOFACIAL REHABILITATION

The use of lasers in the maxillofacial prosthetics is usually for the initial work up of three- dimensional addition of optical data of the extra-oral defects. Laser technology has showed to be useful for designing the shape and position of the prostheses. Lasers can remove the need for conventional impression techniques and related disadvantages like distortion of the soft tissue and irritation to patients. Lasers also overcome the disadvantages of 3D CT and MRI reconstruction as the patient is not uncovered to considerable radiation and any stress.²⁸

FURTHER SCOPE OF RESEARCH

Various Continuing Dental Education (CDE) programs, lectures, workshops, conferences, and courses are obtainable to help the dentist and staff learns and master laser techniques. The Academy of Laser Dentistry (ALD) is one such organization faithful to clinical education, research, and the development of standards and guidelines for the safe and successful use of laser technology worldwide. Founded in 1993, ALD involves among its members top clinicians, academicians, and researchers in all laser wavelengths. The main aim of these courses and academies is to understand laser

physics, and further safe and successful use of lasers on patients.

Hard tissue laser applications like crown preparations, bone recontouring and implant placement are undertaking quick changes in technologic advances. Through the continous development of laser technology, laser dentistry may become a different branch in dentistry.

Photodynamic therapy: Research is ongoing for the treatment of oral cancer using photodynamic therapy (PDT). The advantage of PDT for early carcinomas of the oral cavity is the capacity to protect normal tissues while treating cancers up to 1cm in depth. Clinical studies have shown that PDT is a successful procedure for the treatment of dysplastic, micro-invasive and early forms of cancer.^{2,29}

CONCLUSION

The possible for laser dentistry to upgrade dental methods in the dentist's ability to control the power output and the duration of exposure on both hard and soft tissues, permit for treatment of a highly particular area of focus without damaging surrounding tissues, he or she requires to fully understand the character of the wavelength being used, and the thermal inference & check of the optical energy. However, the future of the dental laser is bright with some of the newest ongoing research. From operative dentistry to periodontics, paediatrics and prosthetics to cosmetics and implantology, Lasers have made a huge effect on the distribution of dental care in the 21st century and will persist to do so as the technology continues to enhance and progress.

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Source of Support: Nil
Conflict of Interest: Nil