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Review Article

Role of Laser Therapy in Dentistry: A Review

Richa Wadhawan*[1], Gaurav Solanki[2], Aditya Bhandari[3], Anjana Rathi[3] and Rashmi Dash[3]

[1] *Senior Lecturer, Oral Medicine, Radiology & Diagnosis, Jodhpur Dental College & Hospital, Jodhpur, Rajasthan, India.*
[2]*Intern, Jodhpur Dental College & General Hospital, Jodhpur, Rajasthan, India.*
[3]*Third year student, Jodhpur Dental College & General Hospital, Jodhpur, Rajasthan, India.*

***Correspondence Info:**
Dr. Richa Wadhawan,
Senior lecturer, Oral Medicine, Radiology & Diagnosis,
Jodhpur Dental College & Hospital, Jodhpur, Rajasthan, India
E-mail: richawadhawan@gmail.com

Abstract

Lasers were introduced into the field of clinical dentistry with the hope of overcoming some of the drawbacks posed by the conventional methods of dental procedures. Since its first experiment for dental application in the 1960s, the use of laser has increased rapidly in the last couple of decades. At present, wide varieties of procedures are carried out using lasers. The aim of this review is to describe the application of lasers in various fields of dentistry. Based on recent advancements and the propagation of minimum intervention principles, lasers may revolutionize various surgical & non surgical aspects of dentistry. This article describes how laser can be used for a variety of dental procedures such as cavity preparation, caries removal, restoration removal, etching, and treatment of dentinal sensitivity & management of soft tissue lesions. The fundamentals of laser physics and tissue interaction are explained.

Keywords: Lasers, Hard Tissues, Soft Tissues, Diode lasers, CO_2 lasers, Erg: YAG lasers.

1. Introduction

The word LASER actually stands for Light Amplification by Stimulated Emission of Radiation. Laser light is different from regular light. It has a single wavelength and can be focused in a very narrow beam. This makes it both powerful and precise. The use of lasers in dentistry has increased over the past few years. The first laser was introduced into the fields of medicine and dentistry during the 1960s. Since then, this science has progressed rapidly. Because of their many advantages, lasers are indicated for a wide variety of procedures.[1] Laser technology is developing with phenomenal speed, and new lasers with broad characteristics are available for use in different fields of dentistry. Laser therapy is based on induction of biologic response through energy transfer. The devices emitted wavelength determines the effective depth of penetration. 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.[2] When a medium-which can be gas, liquid, solid or free particle—is stimulated by an energy source in a controlled and methodical manner, the light emitted is of a single wavelength particular to the medium (i.e, monochromatic) and is intense or high energy, coherent (travels in a constant phase in time and space), and collimated (travels in the same direction). Such properties enable the light beam to penetrate tissue in order to incise the tissue, seal blood vessels and nerves, and char and vaporize diseased tissue. Effects of laser are dependent on the type of laser used, as well as on the type of tissue, since a particular tissue may transmit, absorb, scatter or reflect the laser light. Transmission of energy does not have any effect on the tissue but can result in damage to deeper structures. The tendency of tissue to absorb laser energy determines the final effect of the laser. Different wavelengths are absorbed to various extents by different types of tissue, causing the tissue to disintegrate due to heat, chemical reaction, or mechanical disruption. Laser medicine is the use of various types of lasers in medical diagnosis, treatment, or therapy.[3]

Based on power, lasers can be classified into the following three categories:

***I. High–Power Lasers (Hard, Hot)*:** These lasers increase tissue kinetic energy and produce heat. As a result, they leave their therapeutic effects through thermal interactions. These effects include necrosis, carbonization, vaporization, coagulation and denaturation. These lasers usually have an output power of more than 500 mW.

***II. Intermediate–Power Lasers*:** These lasers leave their therapeutic effects without producing significant heat. To shorten treatment period length and to accelerate the therapeutic effect in some cases, low-power lasers are replaced by intermediate lasers with output powers ranging from 250-500 mW.

***III. Low-Power Lasers (Soft, Cold)*:** These lasers have no thermal effect on tissues and produce a reaction in cells through light, called photo biostimulation or photo biochemical reaction. Output power of these lasers is less than 250 mW.[4]

2. Mechanism of Action of Lasers

Lasers are the direct application of light energy with biomodulatory capacity on body cells. Photo acceptors (cytochrome c oxidase) can absorb low level lasers irradiation and transfer it inside mitochondria in order to provide cell energy (ATP) which is the product cytochrome c oxidase and Krebs cycle. In final the stimulation of ATP synthesis results in increased cell activity. Biomodulatory effects of low level laser therapy comprise the following: macrophages, lymphocytes, fibroblasts, endothelial cells and keratinocytes proliferation; increase ATP synthesis and cell respiration, growth factors and other cytokines release, change of fibroblasts to myofibroblasts; change in inflammatory mediators level (histamine and prostaglandins); increase in oxygen transport and improve in glucose consumption; changes in cell membrane potential and permeability, sodium/potassium pump excitation and more calcium removal, vasodilatation , angiogenesis & collagen synthesis.[5]

3. Analgesic Effects of Laser

Stimulation of any point of the body creates neural impulses that are transmitted to upper nervous centres by neurons that have different features. These impulses finally reach the CNS. Low-power lasers can leave their effects in different parts of the body. Currently the following analgesic effects are recognized: Low-power lasers inhibit the release of mediators from injured tissues. In other words, they decrease concentration of chemical agents such as histamine, acetylcholine, serotonin, H+ and K+, all of which are pain mediators. Low-power lasers inhibit concentration of acetylcholine, a pain mediator, through increased acetylcholine esterase activity. They cause vasodilatation and increase blood flow to tissues, accelerating excretion of secreted factors.

On the other hand, better circulation leads to a decrease in tissue swelling. They decrease tissue edema by increasing lymph drainage. They also remove the pressure on nerve endings, resulting in stimulation decrease. These lasers decrease sensitivity of pain receptors as well as transmission of impulses. They decrease cell membrane permeability for Na + and K + and cause neuronal hyperpolarization, resulting in increased pain threshold. Injured tissue metabolism is increased by electromagnetic energy of laser. This is induced by ATP production and cell membrane repolarization. Low-power lasers increase descending analgesic impulses at dorsal spinal horn and inhibit pain feeling at cortex level. They balance the activity of adrenalin and noradrenalin system (autonomous system) as a response to pain. Low-power lasers increase the urinary excretion of serotonin and glucocorticoids, increasing the production of β-endorphin.[6]

4. Lasers in periodontics[7, 8]

i) Gingivectomy
ii) Gingivoplasty
iii) Operculectomy
iv) Gingival troughing
v) Crown lengthening
vi) Sulcular debridement (removal of diseased or inflamed soft tissue in the periodontal pocket)
vii) Flap surgery
viii) Soft tissue management around the abutments
ix) Tissue retraction for impressions
x) Removal of granulation tissue from bony defects
xi) Laser soft tissue curettage of the post-extraction tooth sockets and the periapical area during apical surgery
xii) Guided tissue regeneration
xiii) Oral papillectomies
xiv) Reduction of gingival hypertrophy
xv) Excision of epulis, papilloma, fibroma or any other exophytic growth

Erbium lasers show potential for effective root debridement. The Er:YAG laser has been shown, in vitro, to remove calculus and to negate endotoxin. Clinical data also exist that suggest the Er:YAG laser can result in a superior calculated clinical attachment gain compared with mechanical scaling and root planing alone. [9, 10]

Table 1: Lasers in conservative dentistry & endodontics [11,12,13,14]

Hard tissue	• Class I, II, III, IV and V cavity preparation • Caries removal • Restoration removal • Hard tissue surface roughening and etching • Enameloplasty, excavation of pits and fissures for placement of sealants. • Hypersensitive dentin • Aid in detection of caries.
Root canal	Tooth preparation to obtain access to a root canal • Root canal preparation including enlargement • Root canal debridement and cleaning • Pulpotomy as an adjunct to root canal therapy
Endo surgery	• Flap preparation – incision of soft tissue to prepare a flap and expose the bone. • Cutting bone to prepare a window access to the apex (apices) of the roots • Apicoectomy – amputation of the root end • Root end preparation for retro fill amalgam or composite • Removal of pathological tissues (i.e., cysts, neoplasm or abscess) and hyperplastic tissues (i.e., granulation tissue) from around the apex.

The vast majority of the lasers cleared for market since the last Council Statement on Lasers in 1998 that are intended for hard tissue applications, such as the ablation of caries, enamel, and dentin are either the Er:YAG (2.94 µm) or the Er,Cr:YSGG (2.78 µm) laser. Erbium hard tissue lasers have the capability to prepare enamel, dentin, caries, cementum and bone in addition to cutting soft tissue. The ability of hard tissue lasers to reduce or eliminate vibrations, the audible whine of drills, micro fractures, and some of the discomfort that many patients fear and commonly associated with high-speed hand pieces is impressive. In addition, these lasers can be used with a reduced amount of local anaesthetic for many procedures.

Today, these instruments have evolved from their initial use for all classes of cavity preparations to their ability for removing soft tissue, their usefulness in the disinfection of bacteria within endodontic canals. All conventional dental instrumentation, either hand or rotary, must physically touch the tissue being treated, giving the operator instant feedback. As mentioned, dental lasers can be used either in contact or out of contact.[15]

Clinically, a laser used in contact can provide easy access to otherwise difficult to reach areas of tissue. The fiber tip can easily be inserted into a periodontal pocket to remove small amounts of granulation tissue, for example. In non-contact, the beam is aimed at the target at some distance away from it. This modality is useful for following various tissue contours, but the loss of tactile sensation demands that the surgeon pays close attention to the tissue interaction with the laser energy. Brugnera *et al* used He-Ne low-power laser to treat 300 patients with dentin hypersensitivity in 1995-1997. Corona *et al* showed that Ga-Al-As low-level laser has the same effect as fluoridated varnish. Several studies examined the possibility of using laser to prevent caries.

It is believed that laser irradiation of dental hard tissues modifies the calcium to phosphate ratio, reduces the carbonate to phosphorous ratio, and leads to the formation of more stable and less acid soluble compounds, reducing susceptibility to acid attack and caries. A diode laser can be used at second stage surgery instead of a scalpel. Esthetics and smile has become important issues in modern society. Bleaching has become the common method for tooth whitening. Bleaching using diode lasers results in immediate shade change and less tooth sensitivity and is preferred among in office bleaching systems.[16]

Table 2: Laser in oral surgery [17, 18, 19, 20]

Bone	• Cutting, shaving, contouring and resection of oral osseous tissues • Osteoplasty and osseous recontouring (removal of bone to correct osseous defects and create physiologic osseous contours) • Ostectomy (resection of bone to restore bony architecture, resection of bone for grafting, etc.) • Osseous crown lengthening • Vestibuloplasty • Sinus Lift procedure The yttrium-scandium-gallium-garnet (YSGG) laser is the optimal choice for not cutting the sinus membrane. The YSGG laser can also be used to make the osteotomy for a ramal or symphyseal block graft. • Wound healing post extraction & surgical procedures • Frenectomy • Frenotomy • Incision & drainage of abscesses • Drainage of fistulas • Uvuloplasty

Diode lasers are attracted to pigment, and frenums are typically thicker fibrous tissue and have very little pigment to them. The lack of pigment and more fibrous nature of the tissue mean that higher energies and some patients are required to ablate this tissue. Other wavelengths such as Er:YAG lasers may ablate frenums faster, and can be used in non contact mode, but the drawback compared to diode lasers is an increased risk of bleeding.[21]

Table 3: Lasers in pediatric dentistry[22, 23, 24]

Operative advantages	• Safety • No rotary instruments used • Less post operative discomfort • No vibration & no contact of rotator instruments • Painless • Reduction of need for local anaesthesia • During soft tissue procedures, haemostasis can be obtained without the need for sutures in most cases. • Reduced operator chair time
Clinical advantages	• Minimal invasive cavity preparation • Bactericidal effect • Haemostatic effect • Direct and indirect pulp capping • Good soft tissue healing • Improvement of patient approach

Table 4: Lasers in prosthodontics [25, 26]

Fixed Prosthetics/Esthetics	i. Crown lengthening ii. Soft tissue management around abutments iii. Osseous crown lengthening iv. Troughing v. Formation of ovate pontic sites vi. Altered passive eruption management vii. Modification of soft tissue around laminates viii. Bleaching i x Veneer removal
Removable Prosthetics	i.Treatment of undercuts ii Tuberosity reduction iii.Torus reduction iv.Soft tissue modification v. Epulis fissurata vi. Denture stomatitis vi. Residual ridge modification
Implants	i) Implant recovery ii) Implant uncovering iii) Implant site preparation iv) Peri-implantitis

4.1 Fixed prosthetics/Esthetics

One of the essential elements of success of lasers in fixed prosthodontics is the care and accuracy of the component treatment stages and the laser often can confer minimal collateral tissue damage through proper consideration of the use of minimal laser energy of the correct wavelength. Argon laser energy has peak absorption in haemoglobin, thus lending itself to providing excellent haemostasis and efficient coagulation and vaporization of oral tissues. The removal and recontouring of gingival tissues around laminates can be easily accomplished with the argon lasers.

4.2 Osseous Crown Lengthening

Like teeth mineralized matrix of bone consists mainly of hydroxyapatite. The water content and hydroxyapatite are responsible for the high absorption of the Er:YAG laser light in the bone. For favourable pontic design recontouring of soft and bony tissue may be needed. Soft tissue surgery may

be performed with any of the soft tissue lasers and osseous surgery may be performed with erbium family of lasers. Altered passive eruption management: Lasers can be used very efficaciously to manage passive eruption problems when the patients have clinical crowns that appear too short or when they have an uneven gingival line producing an uneven smile, excessive tissue can be easily and quickly removed without the need for blade incisions, flap reflection, or suturing.[27]

4.3 Laser Troughing

Lasers can be used to create a trough around a tooth before impression taking. This can entirely replace the need for retraction cord, electrocautery and the use of haemostatic agents. The results are predictable, efficient, minimize impingement of epithelial attachment, cause less bleeding during the subsequent impression, reduce postoperative problems and reduce chair time. It alters the biological width of gingiva. Nd: YAG laser is used. Veneer removal: With laser technology, the restoration can now be removed without cutting it off. The laser energy passes through porcelain glass unaffected and is absorbed by the water molecules present in the adhesive. It appears that this debonding occurs at the silane– resin interface because the underlying tooth structure appears to be unaffected.[28]

4.4 Implantology

Dental lasers are used for a variety of procedures in implantology. Following the placement of an implant and its integration into the osseous substrate, the current method of treatment is to surgically uncover the implant, wait for the tissue to heal, and then proceed with impressions and fabrication of the restoration. The reason for the delay is to facilitate the impression - taking process. Use of lasers can greatly expedite this procedure because the implant can be uncovered and impressions can be obtained at the same appointment. All types of lasers can be used to expose dental implants. In addition the use of laser can eliminate the trauma to the tissues of flap reflection and suture placement. Implant site preparation: Lasers can be used for the placement of mini implants especially in patients with potential bleeding problems, to provide essentially bloodless surgery in the bone. Lasers can also be used to remove granulation tissue in case there is inflammation around an already osseointegrated implant.[29]

4.5 Removable Prosthetics

The most common reason for enlarged tuberosities usually is soft tissue hyperplasia and alveolar hyperplasia accompanying the over-eruption of unopposed maxillary molar teeth. Surplus soft tissue should be excised, allowing room for the denture bases. Persistent trauma from a sharp denture flange or over compression of the posterior dam area may produce a fibrous tissue response. The soft tissue reduction may be performed with any of the soft tissue lasers. Erbium laser is the laser of choice for the osseous reduction. [30]

5. Lasers in Oral Medicine

Laser surgery has become a reliable treatment option for oral carcinoma as well as for potentially malignant lesions. Widely used lasers in oral and maxillofacial tumor surgery are the CO_2 laser, the Er: YAG laser, the Nd: YAG laser and the KTM laser. Laser vaporization offers a precise means of treating oral lesions that reduces the potential for pain and scarring. Oral lesions treated with laser surgery include aphthous ulcers, lymphangiomas, hemangiomas and verrucous carcinomas.[31] Donnarumma *et al* have postulated a mechanism of action that laser irradiation "acts in the final stage of HSV-1 replication by limiting viral spread from cell to cell and that laser therapy acts also on the host immune response unblocking the suppression of pro-inflammatory mediators induced by accumulation of progeny virus in infected epithelial cells."

Very little difference in the appearance of the lesion will occur, other than at times when the diode is used in the vesicular stage of herpetic lesions the dentist will note that the lesion "dries up" with laser therapy.[32] In photodynamic therapy (PDT), photosensitizing agents are "turned on" or activated by a certain wavelength of light. For example, an argon laser can be used in PDT. When cancer cells that contain the photosensitizing agent are exposed to red light from this laser, it causes the chemical reaction that kills the cancer cells. Light exposure must be carefully timed so that it is used when most of the agent has left healthy cells, but is still in the cancer cells.

CO_2 laser and diode laser has been found useful for the treatment of vascular anomalies of the oral cavity and concluded that laser is a suitable tool for the treatment of these lesions and sometimes the laser cannot remove the entire tumour in one treatment, so more treatments may be needed. Infrared laser photodynamic therapy over the projection of the sinuses will lower the sensation of pressure and tenderness. Irradiation into the nostrils will reduce the mucosal swelling and open the nasal obstruction. Thus, dental treatment can become more comfortable. To actually cure sinusitis, repeated irradiations are needed.[33] Infrared low level laser therapy proved to be a valuable alternative for burning mouth syndrome treatment, providing a significant and lasting reduction in symptoms. Laser photodynamic therapy can be used to stimulate the salivary flow in patients with xerostomia.[34]

Recent studies suggest that the effect is not only transient. Reduction of pain is one of the most desired effects of laser therapy. This is obvious in dentistry where pain is one of the most feared situations. Pain reduction requires higher doses than general stimulation and therefore pain reduction and tissue stimulation cannot be achieved at the same time. Pain can be gradually reduced by the ability of laser photodynamic therapy to shorten the period of inflammation, but the dose window for this is lower than that of immediate pain reduction. Laser photodynamic therapy stimulates opioid precursors and causes transient axonal vesicles that reduce neural transmission. Trigeminal neuralgia and post herpetic neuralgia are two indications suitable for LPT. Photodynamic therapy, or phototherapy, can be administered topically or parenterally. The mechanical effects of laser are utilized in the removal of tattoos and in lithotripsy procedures (eg, the removal of salivary stones).[35]

5.1 Temporo-mandibular Joint Disorders (TMD)

TMD can be either arthrogenic, myogenic or both in combinations. The effect of laser photodynamic therapy on arthritic conditions is well investigated and there is some evidence of an effect on myogenic pain and trismus. For arthrogenic conditions, low doses are required whereas myogenic conditions require an infrared laser and high dosage. The pain and spasm relieving effects are fast and the condition of trismus can be resolved or improved within minutes. Because the occipital and neck muscles are frequently involved in TMD, the laser will add benefits for the dentist and patient. Patients with stiff necks are difficult to treat and a session of laser therapy can soften the neck. In addition, irradiation over the joint and masseter after surgery will decrease the postoperative consequences of a long period of overstretched muscles.[36]

5.2 Effect of Low-Level Laser on Myo-facial Pain

Several studies have shown that use of 830-nm wavelength diode laser in several appointments can reduce or eliminate myofacial pain. Altofini *et al* reported no pain in their patients up to 3 months. Furthermore, effectiveness of laser acupuncture has been confirmed in decreasing myofacial pain.[37]

5.3 Effect of Low-Level Laser on Mucositis Pain

Maiya & Fernande showed that in patients who had oral mucositis because of radiotherapy of neck and head region, exposure to 632.6 nm wavelength decreased pain more than that in those who received oral analgesics or topical anaesthesia. Mucositis pain following chemotherapy can also be reduced by low-level laser with a wavelength of 650 nm. [38]

5.4 Lasers in Orthodontics

There is some documentation for the use of laser therapy to reduce the pain experienced during tooth movements and also to increase the velocity of tooth movement. Low dosage seems to accelerate the speed of movement whereas higher dose appear to slow down movement. In the latter case, this could possibly be used for stabilization of completed orthodontic therapy. Laser photodynamic therapy has also been proposed as a viable option for luxated teeth before applying orthodontic stabilization.[39, 40.]

6. Conclusion

Lasers offer many useful clinical applications for general dentists in the diagnosis and treatment of patients, as long as the clinician receives the proper training to use this technology safely and effectively. There are many clinical, aesthetic, and psychological reasons to use lasers. Improvements in laser technology allow new procedures and broaden the scope of applications for both diagnosis and therapy.

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