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A REVIEW ARTICLE

LASER IN PERIODONTICS- A REVIEW

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ABSTRACT

The use of lasers in dentistry has been considered for more than 20 years. The laser has been one of the most exciting technologies in the dental practice since Maiman invented the ruby laser in 1960. Lasers were introduced to the field of clinical dentistry in hopes of overcoming some of the drawbacks posed by conventional methods of dental procedures. Higher energy density lasers were shown to melt enamel, but were potentially dangerous. Subsequently, low energy density laser radiation was shown to affect the formation of artificial carious lesions and soft tissue management.

KEYWORDS: Laser, periodontics, radiation, laser dentistry.

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INTRODUCTION

Laser which stands for Light Amplification by Stimulated Emission of Radiation, was first developed by Maiman (1) a scientist, using ruby crystal that emits coherent radiant light when stimulated by theory-based energy originally postulated by Albert Einstein. Goldman (2), who was experimenting with lasers for tattoo removal, showed a painless cracking of the enamel surface after focusing two pulses of red light from the ruby crystal. After the experiments of Stern and Sognnaes (3), the pendulum switched from ruby laser to CO2 and Nd: YAG laser for better interaction with hard dental tissues.

Lasers have been used extensively in medicine and surgery since the 1960s. Lasers designed for surgery deliver concentrated, controllable energy to tissues. For a laser to have a biological effect, energy must be absorbed. the degree of absorption into the tissue will vary depending on the wavelength and optical characteristics of the target tissue. If the maximum laser emission coincides with the absorption spectrum of one or more components of the target tissue, a predictable and specific interactive effect will be produced.

HISTORICAL BACKGROUND (4):

- 1917-Stimulated emission: Albert Einstein
- 1959-Principle of MASER: Schawlow and Townes
- 1960-Synthetic ruby laser: Theodore Maiman
- 1961-The first gas laser and first continuously operating laser: Javan *et al.*
- 1964-Treatment of caries: Goldman
- 1968-CO_2 laser: Patel *et al.*
- 1971-Tissue reactions to laser light and wound healing: Hall and Jako *et al.*
- 1974-Nd: YAG laser: Geusic *et al.*
- 1977-Ar laser: Kiefhaber
- 1988-Er: YAG laser: Hibst and Paghdiwala
- 1989-Nd: YAG laser, soft tissue surgery: Midda *et al.*

BASIC SCIENCE AND CONCEPTS OF LASER:

The laser is a monochromatic light in the visible or invisible field with three main characteristics: collimation, coherence and efficiency. The photon wave produced can be defined by measuring its speed, amplitude and wavelength (5).

The amplification takes place in the optical cavity present in the center of the laser device, which has two parallel mirrors, one at each end, and the core of this cavity is composed of chemical elements, compounds or molecules, in gaseous, crystalline or solid-state semiconductor form. known as the active medium, which gave the laser its generic name (5). The drive source, a stroboscopic device with a flash lamp or an electric coil, surrounds the optical cavity that supplies power to the active medium (Figure 1).

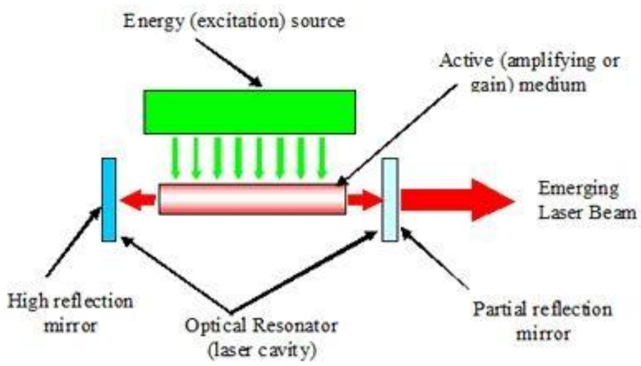

Figure:1

Other mechanical components include the cooling system, focus lens, and other controls. Based on the quantum theory of physics proposed by Max Plank (6) and on the atomic architecture of Niels Bohr (7), spontaneous emission can be defined as the process by which a light source i.e., an atom, a molecule, a nanocrystal /a nucleus, in an excited state undergoes a transition to the ground state and a photon is emitted.

In a laser, atoms are held in an excited state by "pumping" the laser and some photons are inserted causing the stimulated emission of an atoms, and the resulting photons will cause the stimulated emission of other atoms, which leads to a chain reaction, which will produce intense, coherent and easily focusable light (5). 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 from approximately 500nm to 10600nm and are located within the non-ionizing portion of the visible or invisible infrared of the electromagnetic spectrum that emits thermal radiation. Commonly used lasers in dentistry are CO2, Nd: YAG, Ho: YAG, Er: YAG, Er, Cr: YSGG, Nd: YAP, GaAs and argon (8). The laser beam can be delivered from a flexible hollow waveguide or from a tube with a mirror-like internal finish or from a glass fiber optic cable, in three different emission modes; continuous wave, pulsed closed mode and pulsed free running or true pulse mode.

The main effect of laser energy is photothermal; this effect on the tissue depends on the degree of temperature increase and the corresponding reaction of interstitial and intracellular water (5). The optical properties of the periodontium, such as pigmentation, water content and mineral content, heat capacity and latent heat of transformation, also dictate clinical application in addition to specified wavelength, conduction and heat dissipation, the degree of inflammation and vascularity of the tissue and the availability of progenitor cells for healing. (8).

The characteristics of a laser depend on its wavelength (Table 1). Wavelength affects both clinical applications and laser design. The laser wavelength used in medicine and dentistry generally ranges from 193nm to 10,600 nm, representing a broad spectrum from ultraviolet to far infrared.

Since the beams of both lasers are in the infrared range, they are not visible. Therefore, these lasers often use a quartz fiber that incorporates a 630nm (red) coaxial helium-neon laser into the device to act as a targeting beam and thus ease of use.

LASER WAVELENGTHS:

TABLE 1:

LASER	WAVE LENGTH (in nanometers)
Excimer	193-348
Argon (Ar)	458-515
Potassium Titanyl Phosphate (Ktp/532)	632
Helium-Neon (He-Ne)	637
Diode	819
Neodymium: Aluminum-Yttrium-Garnet (Nd: Yag)	1064
Holmium: Yag (Ho: Yag)	2000-2200
Erbium: Yag (Er: Yag)	2600-2900
Erbium,Chromium:Yttrium-Scandium-Gallium- Garnet (Er, Cr:Ysgg)	2780
Carbon Dioxide (Co_2)	10600

CLINICAL APPLICATIONS:

Initial periodontal therapy

Initial periodontal therapy includes non-surgical debridement of the tooth structure, local drug administration, host modulation, and reduction of sulcular bacteria with laser coagulation of the treatment site (9, 10). Soft tissue lasers are used as adjuvants or alternatives in periodontal therapy to reduce soft tissue inflammation (11).

It photothermally reduces bacterial populations and also eliminates antimicrobial problems such as resistance, allergies and side effects, so it can also be used in children and pregnant women (5,11). Bacterial reduction and coagulation,

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soft tissue lasers such as argon (12) (488 nm, 514 nm), diode lasers (13) (800-830 nm, 980 nm) and Nd: YAG (13-15) (1064 nm) are a used for dark tissue inflamed by periodontal disease and pigmented bacteria. Laser energy is delivered through a thin, flexible fiber optic system and is well absorbed by melanin, hemoglobin and other chromophores, but is transmitted through water and poorly absorbed by hydroxyapatite (5).

It is well absorbed by hydroxyapatite and water, Er, Cr: YSGG (2790nm) and it can also be applicable for soft tissue therapy when used with care by keeping the fiber in contact with the target tissue and the in vitro study has showed a significant bactericidal effect on P. gingivalis and A. actinomycetemcomitans (16). Pocket laser thermolysis uses argon laser in combination with root scaling and smoothing to reduce pathogens within the pocket.CO2 and Nd: YAG lasers, Er: YAG and Er, Cr: YSGG (19) lasers are capable of selective removal of subgingival tartar at a level equivalent to that provided by scaling and planning root (20). Er: YAG has been shown to remove subgingival tartar without a thermal change of the root surface (21,32,33) similar to the ultrasonic scaler with cement ablation of 15-30 µm (10). Rechmann (23) suggested the selective removal of supragingival and subgingival tartar and dental plaque without ablation of the underlying cement or enamel with a dual frequency (337 nm) alexandrite laser.

Soft tissue surgical applications

With the beneficial properties over conventional scalpel including relative ease of soft tissue ablation, hemostasis (20), instant sterilization, reduced bacteremia, reduced wound contraction, reduced edema, minimal scarring, reduced mechanical trauma, minor operative and postoperative pain (8, 24, 25), faster healing, greater patient acceptance (8), few or no sutures and no or no topical anesthesia required (26), soft tissue laser, i.e. CO2, Nd: YAG, diode, Er : YAG and Er, Cr: YSGG are widely used as a tool for soft tissue gingival procedures such as gingivectomy, frenectomy, gingivoplasty, removal of epulis or benign tumors (20), gingival depigmentation, second stage exposure of dental implants, irradiation of ulcers aphthous, coagulation of gingival graft donor sites (8) and elongation of the soft tissue crown (20). The performance of lasers differs according to their depth of penetration and therefore it is possible to damage the underlying tissues due to thermal effects. In CO2, Er: YAG and Er, Cr: YSGG lasers, the laser light is absorbed in the surface layers and is therefore advantageous, with a quick and easy vaporization of the soft tissues. However, deep penetrating Nd: YAG lasers and diode lasers that have greater thermal effects leave a thicker coagulation area on the treated surface (10,20,26) and are therefore used in a similar way to electrosurgical procedures (9). Finkbeiner (27) suggested the usefulness of the argon laser in welding and welding compared to the conventional method of tissue closure.

Root surface modifications

Root surface modification using CO2, Nd: YAG and diode lasers has been studied with conflicting results and had shown to be related to the energy density and selection wavelength of the laser. Carbonated hydroxyapatite on the root surface is seen to have strong absorption bands in the mid-infrared region, making the Er: YAG laser among the preferred lasers (8). In vitro studies have shown well adherence of fibroblasts after adequate Er: YAG laser irradiation of diseased surfaces compared to mechanical curettage alone (33,34). In contrast to the focused mode, the root conditioning effects of the CO2 laser in the blurry mode prepare the root surface for a favorable attack by fibroblasts (35). Nd: YAG laser irradiation causes reversible changes (36) in the root surface, including surface pitting, crater formation, melting, charring, and carbonization (37), along with an unfavorable attachment by fibroblasts.

Osseous surgery

Since laser-biological tissue interactions are photothermal (8), therefore, while having the added advantages of surgical precision, reduction of collateral soft tissue damage, noise reduction, and vibration elimination with conventional instruments (20), the effect of greater some of the dental lasers on bone are crucial for bone surgery, with the exception of Er: YAG and Er, Cr: YAG (8). The infrared

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spectra of the Fourier transform of the bone surfaces showed the formation of toxic byproducts that delay healing after the Er: YAG laser without water coolant and CO2 laser irradiation (20). Recent clinical applications of the Er: YAG laser in bone surgery have been reported, however its limitations are lower cutting efficiency than conventional instruments and lack of depth control (20).

Implant therapy

The Er: YAG laser has been suggested for the preparation of fixation holes in bone due to its ability to effectively ablate bone tissue during the first phase of implant therapy (20). Prior to the placement of the healing abutment, various lasers were used in the second stage of implant therapy to uncover the submerged implant, with the benefits of improved hemostasis, a finely cut surface, less postoperative discomfort and favorable healing (20).

Due to the difficult and during mechanical debridement, the emergence of bacterial resistance to antibiotics, lasers are now being used for the treatment of peri-implantitis. The Nd: YAG laser is not indicated due to the morphological changes it produces on the implant surface and with CO2 lasers have shown the risk associated with elevated temperature. Among dental lasers, the Er: YAG laser in the appropriate settings has the best property of degranulation and decontamination of the implant surface, without causing alterations of the titanium surface and, like the CO2 laser, does not affect the attachment rate of the osteoblasts.

RECENT ADVANCES

Lasers are now the future of dentistry, making tooth decay removal even more easier. Different types of techniques, protocols and tactics have been introduced that go beyond conventional methods of treatment. Patients expect greater comfort and precision in treatment offered by laser technology.

A. Periowave TM

Periowave TM is a photodynamic disinfection system that using a non-toxic dye (photosensitizer) in terms of low intensity laser. A small amount of blue-colored photosensitizing solution is applied topically to the gums where it binds to microbes and toxins associated with gum or periodontal disease, followed by a low intensity laser directed into the drug-treated region, which causes phototoxic reactions that kill bacteria under the gumline. The treatment takes only 60 seconds so it's quick and painless. (35)

B. Periodontal Waterlase MD

Target applications for Periodontal Waterlase MD are multidisciplinary and restorative dentistry procedures, aesthetic procedures, oral surgery, Endo disinfection, implants and periodontal treatment. Uses minimally invasive periodontal laser therapy shows improvements in bleeding on probing, probing depth and tends to be advantageous over root scaling and planning due to a more effective degree of attachment restoration. (35)

C. Waterlase C100

The targeted applications of Waterlase C100 are restorative procedures, extraction and early periodontal treatment. (35)

D. LANAP

Regeneration refers to the formation of new bone, cement and periodontal ligament. However, it was found that the new laser-assisted fixation procedure (LANAP) could aid in the regeneration of affected periodontal tissues and new cement-mediated connective tissue fixation could be observed. The findings are based on a recent study which confirmed that replacing diseased root tissues with new cement, bone and periodontal ligament reflects periodontal regeneration. Some researchers believe that LANAP will be performed with the Nd: YAG laser (PerioLase MVP-7) promotes periodontal regeneration and also causes minimal bleeding, edema and postoperative discomfort. (36)

E. LAPIP

McCarthy was introduced the concept of LAPIP, "Laser Assisted Peri-implantitis Procedure" as a modification of LANAP, as it can be used in diseased implants. LAPIP helps to restore the diseased structure to a state of health, promotes bone and tissue regeneration and the most commendable feature is that the procedure can be performed on the implants and without damaging it. Since no flaps are reflected, it also leaves scope for other therapies in the future. The LAPIP protocol recommends PerioLase MVP-7, a free-

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running pulsed Nd: YAG laser, for the treatment of peri-implantitis. However, the researchers say that both soft tissue lasers (Nd: YAG, diode, CO_2) and hard tissue lasers can cause deleterious effects on implant surfaces, such as a sudden rise in temperature, as they can impair bone vitality. (36)

HEALING AFTER LASER TREATMENT

Despite the obvious benefits of lasers based on clinical observation and patient acceptance, claims of a faster healing response or decreased scarring, which in turn appear to be wavelength specific and highly sensitive to energy density, they do not find much data to support it (8). Limited animal studies (37-41) involving CO_2, Nd: YAG, diode, or Er: YAG lasers have evaluated histological and immunohistochemical models of periodontal tissue healing following surgical and non-surgical periodontal therapy. Sculean et al (42) and Yukna et al (43) reported the healing response of intraosseous defects after open flap surgery or treatment with a new laser-assisted fixation procedure in humans using Er: YAG lasers. and Nd: YAG respectively. Lippert et al (44) stated that CO_2 laser-induced wounds on the oral and oropharyngeal mucosa that heals significantly faster (within 32.8 ± 9.2 days) than by the Nd: YAG laser (within 40.4 days). ± 9.2). However, unlike conventional scalpel surgery, histological results showed that the onset of wound healing was delayed after surgery and depended on the size of the initial defect. Due to the more pronounced area of necrosis at the base of the wound floor, this effect is most evident with the Nd: YAG laser (44). Although, compared to conventional treatment, it has been shown that, in general (44), in addition to the initial application of the laser for periodontal wound healing (45), a delay has been shown, few studies have reported that laser induced wounds show less tendency for scar contraction than conventional treatment. scalpel (8). Recent studies on low-level laser therapy using GaAIA radiation in the milliwatt range have been shown to positively influence the proliferation of gingival fibroblasts or periodontal ligaments, thus promoting healing of periodontal and peri-implant wounds (45).

CONCLUSION

Lasers have been suggested as an addition or alternative to conventional techniques for various periodontal procedures and are considered superior in ease of ablation, decontamination and hemostasis along with less surgical and postoperative pain.

The same wavelength, different laser parameters will produce different levels of energy density over different periods of time, and therefore different degrees of change in the target tissue. The introduction of lasers in implant therapy and new laser techniques have revolutionized the outcome of periodontal treatment with patient acceptance.

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