Lasers in the field of Dentistry

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Abstract

LASER is an acronym for Light Amplification by Stimulated Emission of Radiation. The use of a laser for treatment has become a common phenomenon in the medical field. The first laser device was made by Maiman in 1960, based on theories derived by Einstein in the early 1900s. They are activated at different power setting modes, and pulse for soft and hard tissues.

Keyword: laser, dental soft and hard laser, Waterlase™

Introduction:

Laser use in dentistry was suggested approximately 100 years ago as a means of using energy generated by light to remove or modify soft and hard tissues in the oral cavity. The radiation involved in generating laser light is nonionizing and does not produce the same effects attributed to X-radiation. Lasers emit light energy that can interact with biologic tissues, such as tooth enamel, dentin, gingiva or dental pulp. The interaction is the effect of the particular properties of laser light including: 1) Monochromaticity, where the light is all the same color (same wavelength): 2) Coherence, where the waves of light are all in phase; and 3) Collimation, where the light rays are parallel to each other and do not diverge. The application of this light energy results in the modification or removal of tissue.[1, 2]

There are special characteristics for the laser light. Laser light is *coherent*, which means that the light is directed in a long distance without divergence, in contrast to the sun or a flashlight. It is *collimated*, which means that the laser light can be concentrated in the target tissue with the highest level of energy in the focus (spot) as well as *monochromatic*, which means that it has only one wavelength. The main part of the laser unit is the *active medium*.

Presently various laser systems have been used in dentistry. Among them Carbon dioxide (CO2), Neodymium-doped: Yttrium-Garnet(Nd:YAG), Semiconductor diode lasers are used for soft tissue treatment. Recently Erbium doped: Yttrium-Aluminium- Garnet (Er:YAG) laser has been used for calculus removal and decontamination of the diseased root surface in periodontal non-surgical, surgical and implant therapy.[3]

In endodontics, lasers have been used as adjuvant treatment in both low-intensity laser therapy and high intensity laser treatment to optimize the outcome of clinical procedures.[4-9] Low-intensity laser therapy induces analgesic, anti-inflammatory and biomodulation effects at a cellular or molecular level, with photochemical responses improving tissue healing processes and less postoperative discomfort for patients. The clinical application of low-intensity laser in endodontic therapy has been considered useful in: postpulpotomy (with the laser beam applied directly to the remaining pulp and on the mucosa toward the root canal pulp); postpulpectomy (with the irradiation of the apical region); periapical surgery (irradiating the mucosa of the area corresponding to the apical lesion and the sutures).[10]

Laser applications in dentistry[11]

The characteristic differences in properties of laser wavelengths explain the variable clinical effects of lasers observed in dentistry. When treating oral soft tissue lesions, two different techniques can be used: excision or ablation. The laser beam can be used in a focused way in order to excise the tissue. Table 1 shows the indications of different laser wavelengths in dentistry.

Table1. Indications of lasers in dentistry[11]

Application	Laser system
Cavity preparation	Er:YAG
Endodontics	Nd:YAG , Diode, Er:YAG
Calculus removal	Er:YAG , ErCr:YSGG
Epithelial removal	CO2, Diode, Nd:YAG , ErYAG
Drug-induced gingival overgrowth	CO2, Diode
Peri-implant gingival overgrowth	CO2, Diode
Peri-implantitis therapy	CO2, Diode, Er:YAG

Soft tissue tumors	CO_2, diode, Nd:YAG , Er:YAG
Pre-prosthetic surgery	CO_2, Diode
Precancerous lesions	CO_2, Er:YAG
Bone removal	Er:YAG , Er,Cr:YSGG
Bleeding disorders	Nd:YAG , Diode, CO_2
Bacterial reduction	PDT, Diode
Phototherapy	Soft lasers

Classification of Lasers[12] Lasers can be classified according its spectrum of light, material used and hardness etc. They are also classified as soft lasers and hard lasers.

Table 2: Classification based on light spectrum

UV Light	100 nm – 400 nm	Not Used in Dentistry
Visible Light	400 nm – 750 nm	Most commonly used in dentistry (Argon & Diagnodent Laser)
Infrared light	750 nm – 10000 nm	Most Dental Lasers are in this spectrum

Table 3: Classification according to material used:

Gas	Liquid	Solid
Carbon Dioxide	Not in clinical use	Diodes, Nd:YAG, Er:YAG, Er:Cr:YSGG, Ho:YAG

1. **Soft lasers[12]**
   Soft lasers are of cold (athermic) energy emitted as wavelengths; those are thought to stimulate cellular activity. These soft lasers generally utilize diodes and the manufacturers claim that these lasers can aid healing of the tissue, reduces inflammation, edema, and pain. Clinical application includes healing of localized osteitis, healing of aphthous ulcers, reduction of pain, and treatment of gingivitis.

   The current soft lasers in clinical use are the:
   - Helium-neon (He-N) at 632.8 nm (red, visible).
   - Gallium- arsenide (Ga-As) at 830 nm (infra-red, invisible).

2. Hard lasers (surgical)
Hard lasers can cut both soft and hard tissues. Newer variety can transmit their energy via a flexible fiber optic cable. Presently more common type clinically used, under this category

The Hard lasers[12]
- Argon lasers (Ar) at 488 to 514 nm
- Carbon-dioxide lasers (CO_2) at 10.6 micro-meter
- Neodymium-doped yttrium aluminum garnet (Nd:YAG) at 1.064 micrometer.

- Holmiumyttrium-aluminum-garnet (Ho:YAG) at 2.1 micro-meter.

- Erbium,chromiummyttrium-slenium-gallium-garnet (Er,Cr:YSGG) at 2.78 micro-meter.
- Neodymiummyttrium-aluminum-perovskite (Nd:YAP) at 1,340 nm.

Types of lasers [13]

On the basis of output energy

- Low output, soft or therapeutic eg. Low-output diodes
- High output, hard, or surgical eg. CO2,Nd:YAG,Er:YAG

On basis of state of gain medium

- Solid state-eg.Nd:YAG, Er:YAG, Er,Cr:YAG
- Gas- eg.HeNe, Argon,CO2
- Excimer-eg. ArF, KrCl
- Diode- eg. GaAIAs

On the basis of oscillation mode

- Continous wave eg. CO2, Diodes
- Pulsed wave eg. Nd:YAG, Er:YAG

Mechanism of action of lasers:

The physical principle of laser was developed from Einstein's theories in the early 1900s, and the first device was introduced in 1960 by Maiman.[13] Since then, lasers have been used in many different areas in medicine and surgery. Laser light is a man-made single photon wavelength. The process of lasing occurs when an excited atom is stimulated to emit a photon before the process occurs spontaneously. Spontaneous emission of a photon by one atom stimulates the release of a subsequent photon and soon. This stimulated emission generates a very coherent (synchronous waves), monochromatic (a single wavelength), and collimated form (parallel rays) of light that is found nowhere else in nature.[14]

Laser is a type of electromagnetic wave generator. Lasers are heat producing devices converting electromagnetic energy into thermal energy. The emitted laser has three characteristic features.

1. **Monochromatic**: in which all waves have the same frequency and energy.
2. **Coherent**: all waves are in a certain phase and are related to each other, both in speed and time.
3. **Collimated**: all the emitted waves are nearly parallel and the beam divergence is very low.[15-17]

What is Waterlase?

Erbium-Chromium doped: Yittrium-Selenium-Gallium-Garnet (Er, Cr: YSGG) laser is commercial available as Waterlase (Fig. I, II). It uses a patented combination of laser energy and water by a process called Hydro photonics, to perform a wide range of dental procedures. Waterlase cuts hard and soft tissue without heat, vibration or pressure, the dentist may be able to perform the procedure without anesthesia. Also, using the Waterlase laser reduces bleeding, post-operative pain and swelling and the need for pain medication in many cases. It can be used for a wide range of hard and soft tissue procedures including decay removal, cavity preparation, root canals, smile design, frenectomy, gingivectomy, gingivoplasty curettage, vestibuloplasty, operculectomy, crown lengthening, flap surgery, removal of granulation tissue and bone surgical procedures and many others.[18]

Uses in general dentistry [19]

The waterlase can be used for the caries removal, class I, II, IV and V cavity preparation, excisional and incisional biopsies, exposure of unerupted teeth, fibroma removal, haemostasis, implant recovery, incision and drainage of abscesses, leukoplakia, oral papillectomies etc.

Advantages of the waterlase

1. It requires no drill or needle for fillings.
2. Increased bond strength for fillings, prepares teeth in a way that maximizes the bonding of tooth colored fillings.
3. Reduced post operative sensitivity with fillings.
4. Effectively performs numerous soft tissue procedures with no suture, little or no bleeding. Much more rapid healing and reduced pain after soft tissue procedures.
5. The Waterlase ™ sterilizes the tooth as it removes decay, which prevents the reoccurance of decay under fillings. The bonding of tooth-colored fillings or protective sealants is maximized allowing them to last longer.[19]

Conclusion

Scientific and medical researchers, as well as the development of present systems, define clearly the field of use of laser in dentistry, widening its therapeutic indications. Currently, among the different types of lasers available, Er:YAG and Er Cr:YSGG laser possess characteristics suitable for dental treatment, due to its dual ability to ablate soft and hard tissues with minimal damage. Application of laser radiation on soft tissues has constituted the first field of clinical use of laser in dentistry. In order to extend the applications in dentistry, researches should be based on the understanding of the effects of various wavelengths and other laser parameters on tissues. Scientific and medical researchers, as well as the development of present systems, will define more and more clearly the field of use of laser radiation in dentistry, widening its therapeutic indications. The Waterlase™ is a revolutionary tool for dentists which are a unique combination of laser energy and water, a process called "hydro photonics" though this new innovative technology seems to be extremely effective, there is a great need to develop evidence based approach to the use of Waterlase™ in dentistry.

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Figure 1. Different laser devices (Nd:YAG) on the left, Er:YAG in the centre and combined Diode and Er:YAG on the right).

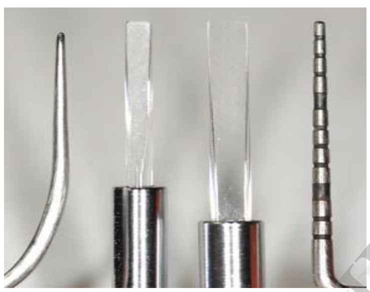

Figure 2. Working tips of ultrasonic scaler (left) Er:YAG laser device (centre) with dimensions comparable to those of periodontal probe (right).

Figure 3. Soft tissue Laser

Figure4. EZLASE^{TM} –A soft tissue diode laser-940nm & 7M, Waterlase hand piece with a fiber optic tip.