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The Magical Effect of Light in Dentistry - A Review

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Abstract

Laser, the magical light in the field of medicine. Introduction to this small magical light in the field of dentistry as well in medicine led to the enormous changes in respective fields in diagnostic as well in therapeutics. The aim of this paper is to focus on various types of lasers and their therapeutic applications in various hard and soft tissue procedures in dentistry.

Keywords: diode lasers, light amplification, photo stimulation, wave length.

Introduction

The word 'LASER' stands for "Light Amplification by Stimulated Emission of Radiation". The principle of the laser was invented and described by Albert Einstein in his theory of stimulated emission in 1917. [1,2] Although its basic principle invented in 1917, but the technology of laser usage came into light in 1960s. Since then, its usage in various medical and dental procedures has increased rapidly and also in the development of advanced laser devices taken place from large device to hand-held portable table top devices. This portable light doing the magical effects in the field of medicine and dentistry in the present era. The present paper highlights the laser history, laser-tissue interaction, types and therapeutic applications in various hard and soft tissue procedures in dentistry.

History of Lasers

In 1917, Albert Einstein laid the foundation for the invention of laser and its principles. Later in 1959, Columbia University graduate student, Gordon Gould introduced laser to the public in his article.[3] but the laser technique was more familiar to the world only after a great effort by Theodore Maim an in 1960 [4], who described the functions of laser and he was the first person to built a laser device using a mixture of helium and neon named "Ruby Laser" emitted a deep red-coloured beam. During the next few years, dental researchers did continuous research in the potentiality of various lasers in the field of dentistry.[5]

In 1961, 1- 3% neodymium-doped: yttrium-aluminium-garnet (Nd: YAG) laser, later the argon laser in 1962 and CO_2 laser in 1964 was developed. [3,6] But the first medical laser to coagulate retinal lesions was ruby laser, which was developed in 1963.[3] And also in dentistry in 1965, Dr. Leon Goldman [7], a dermatologist used ruby laser to remove tattoo from tooth of his dentist brother. He focused two pulses of that red light on a tooth, resulting in painless surface crazing of the enamel. In 1970s and 1980s many researchers conducted studies on CO_2 and Nd: YAG lasers, which were thought to have better interaction with dental soft and hard tissues. But these lasers were overshadowed by ruby laser for a long time until 1990. [8,9] Since then, numerous instruments have been made available for dental use and more are being developed such as low-level laser devices and diode lasers are enormously used in the field of dentistry.

Classification of Lasers

Lasers are classified into various types based on their corresponding wavelengths, the type of power used, the lasing medium used, tissue applicability, hard and soft tissue lasers. Classification based on corresponding wavelengths and light spectrum: [10]

• UV Light spectrum (100 nm - 400 nm)

• Visible light spectrum (400 nm - 750 nm)

• Infrared light spectrum (750 nm - 10000 nm). Most of the dental lasers are in this spectrum.

Based on lasing medium used classified as: [5]

• Gas lasers:

--Argon (Ag)

--Carbon-dioxide (CO_2)

• Liquid:

--Dyes

• Solid:

-- Neodymium doped Yttrium, Aluminium and Garnet (Nd: YAG)

--Erbium: yttrium aluminium garnet (Er: YAG)

–Diode

• Semiconductor:

--Hybrid silicon laser

• Excimers:

--Argon-fluoride

--Krypton-fluoride

--Xenon-fluoride

Based on power; lasers can be classified into the following three categories: [11]

• High-Power Lasers (Hard, Hot >500mW): These produce heat by increasing the tissue kinetic energy. Because of this, they produce therapeutic effects through thermal interactions Such as necrosis, carbonization, vaporization, coagulation and denaturation of tissue.

• Intermediate-Power Lasers (250-500Mw): These produce therapeutic effects without producing significant heat.

• Low-Power Lasers (Soft, Cold<250 mW): They have no thermal effect on tissues. They produce reaction in cells through light by a process called photo bio-stimulation or photo biochemical reaction.

Based on application of Lasers on soft tissue and hard tissue lasers are also classified as: [10]

• Soft lasers:

--Gallium- Arsenide (Ga-As).

--Helium-Neon (He-N).

• Hard lasers (Surgical):

--Argon lasers (Ar)

--Carbon-dioxide lasers (CO2).

--Neodymium-doped yttrium aluminium garnet (Nd: YAG).

--Neodymium yttrium-aluminium-perovskite (Nd: YAP).

--Erbium, chromium. Yttrium-selenium-gallium-garnet (Er, Cr: YSGG).

--Holmium yttrium-aluminium-garnet (Ho: YAG).

Mechanism of action of the Laser

Laser is a monochromatic light with a single wavelength and has three principal parts: An energy source, lasing medium and resonator (two or more mirrors that form an optical cavity). Electrical coil supplies energy to laser system for amplification, the energy is produced and is pumped into an active lasing medium which is contained in an optical resonator, producing a spontaneous emission of photons. Consequently, amplification by stimulated emission takes place when the photons are reflected back and forth through the active lasing medium by the highly reflective surfaces of the optical resonator, prior to their exit via output coupler. The laser light in dental lasers is delivered via fiber-optic cable with hollow waveguide. A cooling system, focusing lens and controls complete the system. The properties of the laser are primarily determined based on the composition of an active lasing medium such as which can be a gas, a crystal, or a solid-state semiconductor. [5,6]

Laser – Tissue Interaction

Based on the optical properties of the tissue, the laser light has four types of interactions with the target tissues. They are: Absorption, Transmission of laser energy, Reflection and Scattering. [Figure 1]

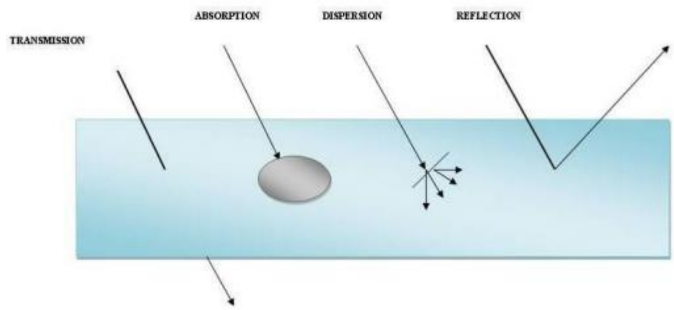

Fig 1: Laser – Tissue Interaction.

Absorption

Application of laser light on the target tissue results laser energy production, which is absorbed or transmitted based on composition of target tissues. Absorption requires an absorber of light known as Chromophores like water, pigment, blood components and minerals. Lasers with different wavelengths have different absorption coefficients with the dental tissues such as water, pigment, blood components and minerals. The longer wavelengths has a greater affinity towards water and hydroxyapatite such as CO2 (10,600nm), whereas shorter wavelengths has a more affinity towards pigmented tissues and blood components such as argon and diode lasers (500 to 1000nm). [5,9] The depth of penetration into the target tissue depends on wavelength of laser light used. The longer wavelength has a lesser penetration depth in tissues 0.03 to 0.1mm such as CO2, where as a shorter wavelength has a deeper penetration depth in tissues 2-5mm such as argon and diode lasers.[5]

Transmission of laser energy

This property depends on the wavelength of laser light and transmission takes place through tissues without causing effect on the target tissue.[5]

Reflection

This property of lasers has no effect on the target tissues, rather it causes damages when redirected to an unintended target tissue such as eyes. The advantage of using this property in caries detecting laser devices to measure the degree of sound tooth structure. [5,9]

Scattering of the laser light

The scattering property of the laser light results in decrease in laser energy which has no biological effects on tissues rather it causes unwanted damage to adjacent tissue by producing heat. [5,9]

So, every oral clinician must be aware of certain factors such as wavelength of lasers, beam diameter, focused or defocused mode, pulse energy, spot size and tissue cooling and be caution before applications of lasers to prevent unwanted damage to adjacent tissues.[9]

Lasers Used in Dentistry: The various types of lasers used in dentistry based on its application on tissues are

Argon Lasers (488nm; 514nm)

Ionized argon gas used as an active lasing medium. The laser light delivered in continuous wave and gated pulsed modes. Based on wavelength it emits two types of laser light such as 488nm (blue) and 514nm (blue green). These laser lights are poorly absorbed by the dental hard tissue and only used for the cutting and sculpting gingival soft tissues, as well used as an aid for caries detection, which appears dark orange-red colour compared to healthy structures.[12] These lasers indicated in periodontics as they posses bactericidal property against Prevotella Intermedia and Porphyromonas gingival is and also used in treating vascular lesions. Potential complications include granuloma formation, bleeding and non-resolution of the lesion.[13]

Diode Lasers (800-1064nm)

lasing medium used as a solid semiconductor crystal made of aluminium (800nm) or indium (900nm), gallium and arsenic. These laser lights are poorly absorbed by the dental hard tissue and are excellent for soft tissue procedures such as gingivoplasty, sulcular debridement, deeper coagulation process on gingival and mucosa. The more chief advantageous of these lasers are smaller in size, portable instrument and at low energy levels stimulate the fibroblastic cells. [5,14]

Nd: YAG Lasers (1064nm)

first developed by Geusic in 1964 and the lasing medium used as a solid-state neodymium doped garnet crystals combined with rare earth elements yttrium and aluminium. These lasers used for soft tissue procedures such as cutting gingival tissues, sulcular debridement with good hemostasis and also indicated for incipient caries removal. At low energy levels used for the treatment of Apthous ulcers or pulpal analgesia.[15]

Er, Cr: YSGG Laser (2780nm)

lasing medium used as a solid-state erbium, chromium doped yttrium scandium gallium crystals. Er: YAG Laser (2940nnm): lasing medium used as a solid-state erbium doped yttrium aluminium garnet crystal. Both the lasers used for caries removal, as it has lesser penetration depth with no or minimal pulpal damage. These lasers has an anesthetic effect and has anti-microbial property. [16,17]

CO2 Laser (10,600nm)

lasing medium used as gaseous mixture with CO_2 molecules. It was first time developed by Patel et al. in 1964.[18] It produces an infra-red light and well absorbed by water molecules and delivered continuous or gated pulsed mode through a hollow tube. The advantageous of this laser is it has good soft tissue cutting efficiency and coagulation of soft tissue as well provides a clear operating field. Best indicated for the treatment of mucosal lesions and to reduce pain by neuron sealing as it act as anaesthetic. One of the limitation of this laser is the penetration depth is approximately 0.2 to 0.3 mm and also has some of the disadvantages such as delayed wound healing and loss of tactile sensation. [19]

Clinical Applications of Lasers

The magical effects of the portable light of lasers plays a major role in the present era in various clinical applications in hard and soft tissue such as therapeutic and diagnostic purposes. [Table 1]

Table 1: Types of lasers for different dental procedures[9]

Dental procedure	Possible types of lasers
Hemostasis	Co2
Laser Doppler flowmetry	He Ne, diodes
Laser fluorescence	He Ne, diodes
Photodynamic therapy to release fibrotic bands in osmf	Er Cr: YSGG
Frictional keratosis, leukoplakia, verrucous carcinoma	Diode
Tuberosity reduction, Alveoloplasty, bone & flap removal	Erbium
Dentine hypersensitivity	Er: YAG
Cavity preparation	Diode
Composite curing	Co2, Nd: YAG, Er: YAG
Removal of defective composite restoration	Argon, Er: YAG
Root canal treatment, apicoectomy	Co2, Nd: YAG
Laser assisted curettage	Nd: YAG, diode
Gingivectomy and gingivoplasty	Co2
Analgesic effect and bio- stimulation of wound healing	He Ne, diode, Nd: YAG

Lasers Application in Soft tissues

Laser Curettage

Nd: YAG and Diode lasers are used most commonly for curettage, due to their antibacterial property particularly against periodontal pathogens such as A. Actino my cetemcomitans and P. gingival is.

Wound Healing

Laser application stimulates proliferation of cells at low doses and suppressive at high doses.[20] Low-level laser therapy (LLLT) shown positive results towards healing of the lesions in the management of recurrent aphthous stomatitis,[21] promotes healing and dentinogenesis following pulpotomy and also in the management of oral mucositis, oropharyngeal ulcerations in patients undergoing radiation therapy. [22,23]

Laser Assisted Biopsy

Incisional and Excisional biopsy was carried out by using lasers with caution. These procedures are accomplished at 100o C where lasers are placed in cutting mode and held perpendicular to the tissue along surgical outline. Interaction of the laser with tissue results vaporization of intra and extracellular water content resulting in ablation or removal of biological tissue. If the temperature exceeds 200o C results in carbonization and irreversible tissue necrosis.[9]

OSMF

Er- Cr: YSGG (Water lase C-100) laser is used most commonly for the management of OSMF. It is used to release the fibrotic bands of oral submucous fibrosis and it works on "hydro-photonic process" in which the energy from the Er-Cr: YSGG laser interacts with water droplets on the tissue to create water molecule excitation, micro expansion and propulsion giving a clean and precise hard-tissue cutting.[9]

Lasers used for Disinfection

Low power lasers are used for disinfection of root canals, in periodontal pockets, deep carious lesions and peri-implantitis sites [24] acts by photochemical activation of oxygen-releasing dyes, causing membrane and DNA damage to the microorganisms such as Gram-positive bacteria (Methicillin-resistant Staphylococcus aureus (MRSA)), Gram-negative bacteria, fungi, and viruses.[25]

Others

The soft tissue lasers such as Gallium- Arsenide (Ga-As) and Helium-Neon (He-N) are indicated for various soft tissue procedures such as for the management of gingival depigmentation, operculectomy, sulcus debridement, gingivectomy / gingivoplasty, pre impression sulcular retraction, removal of granulation tissue (pyogenic granuloma). Pulp capping, pulpotomy and pulpectomy, incisions and draining of abscesses, removal of hyperplastic tissues, vestibuloplasty, frenectomy and treatment of herpetic and recurrent aphthous ulcers. The removal of benign growths such as fibromas or papilloma's are other excisional procedures that can be easily performed using lasers and in addition, LLLT is indicated for oral soft tissue lesions such as nicotinic stomatitis, frictional keratosis, leukoplakia, erythroplakia, and verrucous carcinoma.[26]

Photodynamic Therapy (PDT)

It is a laser-initiated photochemical reaction, where photoactivated dye is used. The laser activation of a sensitizing dye in PDT generates reactive oxygen species (ROS) which in turn directly damage cells and associated vascular network resulting both necrosis and apoptosis.[27] PDT indicated for the treatment of carcinoma in-situ and early lesions of oral squamous cell carcinoma. PDT activates the host immune response and promotes anti-tumor immunity through the activation of macrophages and T-lymphocytes.[28]

Lasers Application in Hard tissues

Lasers for Caries Detection

Due to the fluorescence property of the lasers, used for detection of incipient caries. The bacterial microorganisms and carious tissue exhibit more fluorescence as compared to normal sound tooth structure. [29]

Lasers for Cavity Preparation

Since 1988, the Er: YAG lasers are most commonly used, safe and effective in caries removal and for cavity preparation in paediatric and adult patients without any discomfort. This device also aid in removal of defective composite restoration, glass ionomer cements and ablate the distal carious lesion by preserving the tooth's distal marginal ridge. [30]

Lasers For Dentinal Hypersensitivity

Dentinal hypersensitivity is the one of the most common causes of dental pain. For the management of dentinal hypersensitivity LLLT is most commonly used. These lasers inhibit the release of chemical mediators such as histamine, acetylcholine, serotonin, H+ and K+ from injured tissues.[31]

Lasers For Restoration

The Argon lasers are commonly used for light cured dental restoration materials, which emits high intensity visible blue light (489nm), initiates photopolymerization of restorative material.[32]

Lasers For Bone Surgery and Crown Lengthening

The Er, Cr: YSGG lasers are most commonly used for bone surgeries such as bone cutting, shaving, contouring and for resection. In 2003 Er, Cr: YSGG lasers was first to use for osseous crown lengthening without laying a flap, suturing or damage to the bone, given a positive result.[33]

Limitations of Lasers:[9]

1. As it is a technique sensitive procedure, additional training and education is required for various clinical applications and types of lasers.
2. Equipment is expensive.

3. In a clinical setup based on the procedures and variations in wavelengths more than one laser may be needed.

4. Limited to minor surgical procedures.

Lasers Safety:[34]

- Most of the dental lasers are relatively smaller in size and simple to use by the operator but certain precautions such as protective eye-wear should be taken by the operator and patients to ensure their safe and effective procedures.
- To preventive medico-legal Considerations, informed consent must be followed routinely prior to the initiation of every dental treatment.
- Manufactures safeguard guidelines must be followed to prevent unnecessary exposure to non-target tissues.

Conclusion

Lasers have acquired a specialized place in all disciplines of dentistry making it an amazing spectrum of light. Many types of lasers available for various clinical purposes are activated at different power setting modes, and pulse for soft and hard tissues. As the applications for dental lasers are expanding, greater numbers of dentists are using this technology to provide patients with precision treatment with minimal pain and shorter recovery time. In the emerging future laser technology, might become an essential component in contemporary dental practice.

References

1. Einstein A. Zur Quantentheorie der Strahlung. Physiol Z. 1917; 18:121–8.
2. Aoki A, Sasaki KM, Watanabe H, Ishikawa I. Lasers in nonsurgical periodontal therapy. Periodontol 2000 2004; 36:59-97.
3. Gross AJ, Hermann TR. History of lasers. World J Urol. 2007; 25:217–20.
4. Maim an TH. Stimulated optical radiation in ruby lasers. Nature. 1960; 187:493.
5. Coluzzi DJ. Fundamentals of dental lasers: Science and instruments. Dent Clin North Am 2004; 48:751-70.
6. Verma SK, Maheshwari S, Singh RK, Chaudhari PK. Laser in dentistry: An innovative tool in modern dental practice. Natl J Maxillofac Surg. 2012; 3(2):124-32
7. Goldman L, Gray JA, Goldman J, Goldman B, Meyer R. Effects of laser impacts on teeth. J Am Dent Assoc 1965; 70:601–6.
8. Ishikawa, Frame, Aoki A. Lasers in dentistry, revolution of dental treatment in the new millennium. Amsterdam: Elsevier Science BV 2003;2003.
9. David CM, Gupta P. Lasers in Dentistry: A Review. Int J Adv Health Sci 2015; 2(8):7- 13.
10. Mishra MB, Mishra S. Lasers and its Clinical Applications in Dentistry. Int J Dent Clinics 2011:3(4):35-8.
11. Mokameli S. Principles of Low Power Laser Therapy, 1st ed. Tehran: Boshra; 2004: 7- 8.
12. Kutsch VK. Dental caries illumination with the argon laser. J Clin Laser Med Surg 1993; 11:323-7.
13. Finkbine RL. The results of 1328 periodontal pockets treated with the argon laser: Selective pocket thermolysis. J Clin Laser Med Surg 1995; 13:273-81.
14. Moritz A, Gutknecht N, Doer Budak O, Goharkhay K, Schoop U, Schauer P, et al. Bacterial reduction in periodontal pockets through irradiation with a diode laser: A pilot study. J Clin Laser Med Surg1997; 15:33-7.
15. White JM, Goodies HE, Rose CL. Use of the pulsed Nd: YAG laser for intraoral soft tissue surgery. Lasers Surg Med 1991; 11:455-61.
16. Hossain M, Nakamura Y, Yamada Y, Kimura Y, Matsumoto N, Matsumoto K. Effects of Er, Cr: YSGG

laser irradiation in human enamel and dentin: Ablation and morphological studies. J Clin Laser Med Surg 1999; 17:155-9.

17. Franzen M, Hoort HJ. The effect of Er: YAG irradiation on enamel and dentin. J Dent Res 1992; 71:571.

18. Patel CKN, McFarlane RA, Faust WL. Selective Excitation through vibrational energy transfer and optical Maser action in N2-CO2. Physiol Rev1964; 13: 617-9.

19. Pogrel MA, Muff DF, Marshall GW. Structural changes in dental enamel induced by high energy continuous wave carbon dioxide laser. Lasers Surg Med 1993; 13:89-96.

20. Tominaga R. Effects of He-Ne laser irradiation on fibroblasts derived from scar tissue of rat palatal mucosa. Kokubyo Gakka Zasshi. 1990; 57:580–94.

21. Neiburger EJ. The effect of low-power lasers on intraoral wound healing. NY State Dent J. 1995; 61:40–3.

22. Kurumada F. A study on the application of Ga-As semiconductor laser to endodontics. The effects of laser irradiation on the activation of inflammatory cells and the vital pulpotomy. Ohu Daigaku Shigakushi. 1990; 17:233–44.

23. Kitsmaniuk ZD, Demochko VB, Popovich VI. The use of low energy lasers for preventing and treating postoperative and radiation-induced complications in patients with head and neck Tumors. Vopr Onkol. 1992; 38:980–6.

24. Walsh LJ. The current status of low-level laser therapy in dentistry. Part 2. Hard tissue applications. Aust Dent J. 1997; 42:302–6.

25. O'Neill JF, Hope CK, Wilson M. Oral bacteria in multi-species biofilms can be killed by red light in the presence of toluidine blue. Lasers Surg Med. 2002; 31:86–90.

26. Abraham RJ, Arathy S. Laser management of intraoral soft tissue lesions – A review of literature. IOSR J Dent Med Sci (IOSR-JDMS) 2014; 13:59-64.

27. Dougherty TJ. An update on photodynamic therapy applications Clin Laser Med Surg 2002; 20:3-7.

28. Vowels BR, Cassin M, Boufal MH, Walsh LJ, Rook AH. Extracorporeal photochemotherapy induces the production of tumor necrosis factor-alpha by monocytes: Implications for the treatment of cutaneous T-cell lymphoma and systemic sclerosis. J Invest Dermatol 1992; 98:686-92.

29. Lussi A, Megert B, Longbottom C, Reich E, Frances cut P. Clinical performance of a laser fluorescence device for detection of occlusal caries lesions. Eur J Oral Sci 2001; 109:14-9.

30. Louw NP, Pameijer CH, Ackermann WD, Ertl T, Cappius HJ, Norval G. Pulp histology after Er: YAG laser cavity preparation in subhuman primates – A pilot study. SADJ 2002; 57:313-7.

31. Khalighi HR, Anbari F, Taheri BJ, Bakhtiari S, Namazi Z, Pour Alibaba F. Effect of lowpower laser on treatment of orofacial pain. J Dent Res Dent Clin Dent Prospects 2010; 4:75-8.

32. Fleming MG, Mail let WA. Photopolymerization of composite resin using the argon laser. J Can Dent Assoc. 1999; 65:447–50.

33. owe R. Clinical use of the Er, Cr: YSGG laser for osseous crown lengthening: redefining the standard of care. Pract Proceed Aesthet Dent 2006;18(4): S2-S9.

34. Parker S. Laser regulation and safety in general dental practice. Br Dent J.2007; 202:523–3