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Research Article

LASERS: A SHINE LIGHT ON DENTISTRY WITH A SWEET SOUND OF SILENCE!

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A B S T R A C T

Laser technology is a new breakthrough and its introduction in the field of dentistry has replaced many conventional surgical and technical methods with laser technology with to improve the quality of treatment rendered to the patients. Almost every branch of dentistry has been positively affected with the laser technology including oral surgery, oral medicine, pediatric and operative dentistry, periodontics, prosthetic dentistry& implantology. The ability of the lasers to perform less invasive procedures with minimal discomfort to the patients has made a prodigious impact on the delivery of dental care. This article briefly outlines the basics of lasers and their potential applications in the various fields of dentistry.

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INTRODUCTION

The fear of the dentist, dental pain and noisy dental drill sextants since centuries. The noise from the dental drills is known to generate trauma as similar as physical pain. In order to reduce the patient's fear and torment to dentistry and dental treatment, it became incumbent to develop treatment modalities that are faster, painless, noiseless, provide speedy recovery and hence a better patient compliance. The introduction of lasers into dentistry was one such step. Treatment with lasers that is much less time consuming and painless is well accepted and appreciated by the patient. Lasers have travelled a long way since the development of ruby lasers to erbium lasers and now are being fondly used in every aspect of dental treatment. The term "LASER" originated as an acronym for "Light Amplification by Stimulated Emission of Radiation" termed by Gordo Gould in 1957.[1,2]

Brief History

The principle of the laser was first described by physicist Albert Einstein in his theory of stimulated emission in publication "Zur Quantentheorie der Strahlung" (Quantum Theory of Radiation) in 1917 using a re-derivation of Max Planck's law of radiation, which was conceptually based upon probability coefficients (Einstein coefficients) for the absorption, spontaneous emission, and stimulated emission of electromagnetic radiation.[3]

The credit for discovering the therapeutic use of lasers goes to Theodore Maiman (1960) who demonstrated the laser function by developing the first working laser device known as "ruby laser," which was made of aluminium oxide and emitted a deep red-colored beam.[4] After this invention, dental researchers started investigating the various potentials of lasers. Lasers were introduced to general dental practice by Dr.William and Terry Myers in 1989 by modification of an ophthalmic Nd:YAG laser for dental use after getting clearance by the US Food and Drug Administration (FDA).[1]

Laser Physics[1]: Understanding the laser physics is a pre-requisite before using them. Laser light has three main properties that differentiate it from normal light (Figure 1). They are:-

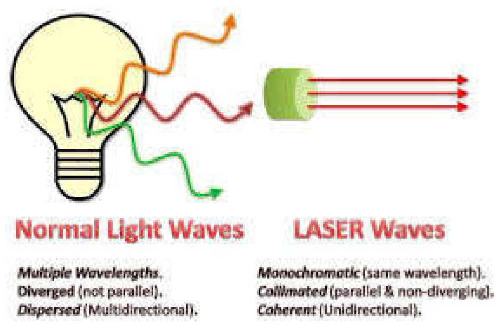

Figure 1 Diagrammatic representation of properties of laser light

Monochromatism: The property of laser light to have one specific color, which can be finely focused is called as monochromacity; in dental applications that color may be visible or invisible.

Collimation: It refers to the beam having specific spatial boundaries, which insures that there is a constant size and shape of the beam emitted from the laser cavity.

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Coherency: It is a distinctive property of lasers which indicates that the light waves produced within the laser instrument are all the same. They are all in phase with one another and have identical wave shapes; that is, all the peaks and valleys are equivalent in frequency and wavelength.

Components of a Laser System

A laser device consists of following components (Figure 2); which is important to understand for the production of laser light.

Active medium: It is an optical cavity at the center of the device. The core of the cavity comprises of chemical elements, molecules, or compounds known as the active medium. This material may be either a naturally occurring or man-made which when stimulated, emits laser light.

Energy source/pumping mechanism: Surrounding the optical cavity is an excitation source, either a flash lamp strobe device, an electromagnetic coil, or a diode unit which provides the energy into the active medium.[1,5,6]

Optical resonator: They are usually mirrors or polished surfaces which are aligned at each end of the optical cavity; there is usually one (distal) high reflective mirror and one (proximal) partially reflective mirror.The parallelism of the mirrors performs amplification and collimation of the developing beam.[5]

Cooling system: Heat is a by-product of laser light propagation. Cooling system helps to lower the temperature of the laser device. Co-axial coolant systems may be air- or water-assisted.[6]

Control panel: Control panel is used to control variable parameters for the output of the laser such as power output with time, pumping mechanism frequency, wavelength change in multi-laser instruments and print-out of delivered laser energy during clinical use.[6]

Delivery system: It is a system through which collimated beam of laser reaches its targeted site/ tissue in an ergonomic and precise manner.[1]

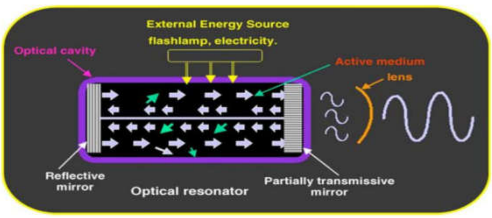

Figure 2 The basic components of a laser system.

Classification of Lasers

Lasers can be classified based on lasing (active) medium

Solid: Eg. Nd:YAG lasers, Er:YAG lasers
Liquid: Eg. Dye lasers
Gaseous: Eg CO_2

According to tissue applicability and penetration

Hard tissue lasers: Eg Erbium lasers
Soft tissue lasers: Eg CO_2 laser

Some common lasers available for the use in dentistry are shown in table 1.[7]

Laser Energy and Tissue Temperature

Oral tissue is a conglomerate which can affect the ideal interaction of a given laser wavelength with a target tissue site. Whenever laser energy is applied to oral tissue, it is imperative for the dentist to understand the biologic rationale for its use. The principle effect of laser energy is photothermalie the conversion of light energy into heat which can lead to the several changes into the targeted tissue sites described in table 2.[1]

Laser Tissue Interaction

The photo thermal effects of laser energy with tissue is divided into - primary and secondary effects (Figure 3). Primary interaction effects includes absorption, transmission, reflection and scattering.

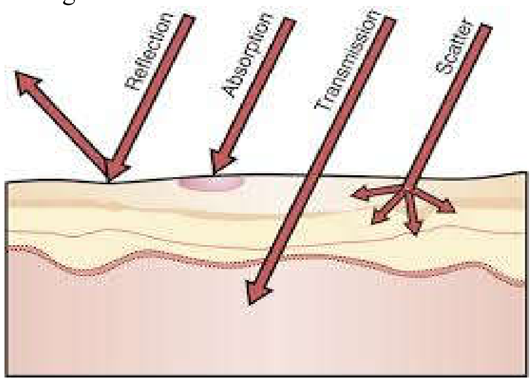

Figure 3 Primary effects of laser tissue interaction

Absorption: It is the primary, desired and most beneficial effect of laser energy by the targeted tissue. The amount of energy that is absorbed by the tissue depends on the tissue characteristics, such as pigmentation and water content, as well as on the laser wavelength and emission mode.

Transmission: The second effect is transmission, the inverse of absorption, where the laser energy travels directly through the tissue with no effect on the target tissue. It is highly dependent on the wavelength of laser light. For example, water is relatively transparent to the shorter wavelengths like argon, diode, and Nd:YAG, whereas tissue fluids readily absorb the erbium family and CO_2 at the outer surface, thus transmitting little energy to the adjacent tissues.

Reflection: The third effect is reflection, where the laser beam redirects itself off of the surface, having no effect on the target tissue.

Scattering: The fourth effect is a scattering of the laser light that weakens the intended laser energy and possibly produce no useful biologic effect. Scattering of the laser beam could cause heat transfer to the tissue adjacent to the surgical site leading to undesirable tissue damage.

Secondary effects of the laser are modified by various factors like laser wavelength, tissue composition, tissue thickness, incident angle of beam, incident energy of beam, emission mode, surface wetness and exposure time. The clinician should choose the laser wavelength that will be absorbed maximally by the target tissue to create maximal surgical effect while not producing any unwanted collateral damage.[1]

Chromophores: The effect of laser depends upon the power of the beam and the extent to which the beam is absorbed.The primary component that absorbs specific laser energy is termed as chromophore.[48]With respect to the chromophores, the anatomic structure of oral tissue will determine whether interaction of the particular wavelength of laser energy will be on the surface or into the deeper tissue. For example, CO_2 laser interacts with its preferred chromophore, water (which is a component of all tissue cells), to ablate the surface of the tissue. While, the preferred chromophore of the Nd:YAG laser is melanin or hemoglobin, which is present in deeper cell layers. Few lasers and their associated chromophores are presented in table 3.

Laser Emission Mode[1]

There are three different laser emission modes

Continuous wave: In this mode of action, the laser beam is emitted at only one power level for as long as the operator depresses the foot switch. While using this mode the operator must cease the laser emission manually to provide thermal relaxation to the tissue. Eg. Diode, CO_2 lasers

Gated pulse mode: The second is the gated-pulse mode, where periodic alternations of the laser energy, much like a blinking light occurs. This mode is achieved by the opening and closing of a mechanical shutter in front of the beam path of a continuous wave emission. This mode provides the time for the targeted tissue site to be cooled before the next pulse of laser energy is emitted thus slowing the amount and rate of tissue removal while simultaneously reducing the chances of irreversible thermal damage to the target tissue and the adjacent tissue. Therefore, thin and fragile tissues should be treated by this mode. Eg. Diode, CO_2 lasers

Free running pulse mode: This mode is also sometimes referred to as ''true pulsed.'' In this operating mode laser emission is unique where large peaks of laser energy in hundreds or thousands of watts are emitted for a short time span, usually in microseconds, followed by a relatively long time in which the laser is off. As the pulse duration is short, the average power experienced by the tissue is small.Eg. Nd:YAG, Er:YAG lasers

Current and Potential Application of Lasers in Dentistry

The use of lasers in a general practice includes the following: fixed, removable, and implant prosthetics; surgical and nonsurgical periodontal therapy; pedodontics; oral medicine, surgery and pathology; endodontics& operative dentistry; and orthodontics.[9-14]

Fixed Prosthetics

- Crown lengthening
- Soft tissue management around abutments
- Gingival retraction
- Formation of ovate pontic sites
- Modification of soft tissue around laminates

Implantology

- Second-stage recovery
- Treatment of peri-implantitis
- Decontamination of implant surfaces

Removable Prosthetics

- Unsuitable alveolar ridges
- Surgical treatment of unsupported soft tissues
- Surgical treatment of tori &exostoses
- Soft tissue corrections- eg Epulis fissurata, Denture stomatitis
- Residual ridge modification
- Soft tissue modification

Periodontics

- Frenectomy
- Gingivectomy
- Graft Periodontal regeneration surgery
- De-epithelialization
- Removal of granulomatous tissue
- Osseous recontouring
- Gingivoplasty
- Removal of calculus deposits and root surface detoxification.

Pediatrics

- Treatment of high frenal attachments.
- Exposure of teeth for orthodontic care.
- Gingival recontouring and gingivectomies in orthodontic patients.
- Pulp therapy in primary teeth.
- Removal of amalgam and other direct restorations.
- Sealant placement.
- Caries removal and tooth preparation.
- Treatment of ankyloglossia

Oralsurgery/Oral medicine/Oral pathology

- Tissue biopsy
- Operculectomy
- Apicoectomy
- Oral soft tissue pathologies

Operative Dentistry and Endodontics

- Pulp diagnosis
- Pulp capping and pulpotomy
- Cleaning and shaping of the root canal system
- Endodontic surgery
- Treatment of dentinal hypersensitivity

Orthodontics

- Frenectomies
- Operculectomy
- Treatment of gingival hyperplasia

Advantages & Disadvantages of Laser Dentistry[15,16]

The lasers can provide the following advantages (Figure 4a & 4b) when properly used by well-trained clinicians

1. Needle-free or ''no anesthesia'' or "Painless" dentistry.
2. Reduced anxiety and fear of drills, "noiseless" dentistry.
3. Creating a more bloodless field because of the ability of producing excellent haemostasis, and sealing of blood vessels, which further leads to superior visualization of the surgical site.
4. Decreased bacterial contamination of the surgical site.
5. Decreasing post-operative swelling.
6. Decreased need for sutures.
7. Reduced overall treatment time.
8. Less mechanical trauma.
9. Less invasive.
10. Better patient compliance.

Figure 4a and 4b Showing various advantages of laser technology.

Disadvantages

1. Mandatory use of glasses for eye protection (patient, operator, and assistants).
2. Inadvertent exposure to irradiation (action in non-contact mode).
3. Risk of excessive tissue destruction by direct ablation and thermal side-effects.
4. High cost of laser apparatus and amortization of the cost remains a matter of concern for the dentist.

Laser Safety[17]

While using a laser, safety is an integral part. There are three facets to laser safety:

The manufacturing process of the instrument: A laser manufacturer must prove the safety and efficacy of that specific device and dental procedure.

Figure 5 Warning displaying ''Laser in use'' sign and the details of laser light being used.

Proper operation of the laser device: An Laser safety officer (LSO) should be assigned who directs laser safety practices and ensures a safe environment while a laser is in use. The ''laser in use'' sign (Figure 5) should be posted in a highly visible area to limit the access of others into the treatment room. The sign should indicate the danger logo, specific wavelength of laser light and the classification. No one should be allowed in the near proximity of the surgical field unless authorized.

The use of personal protective equipments for the surgical team and the patient: Eg mandatory use of eye-glasses. Generally, protective glasses must have an optical density (OD) of at least 4 for the particular laser emission and device. The information about lens protection must be imprinted on the frames of the glasses.

CONCLUSION

Lasers provide a precise and effective way to perform many dental procedures. The incorporation of laser to the dentistry can enhance the dentist's ability to perform more clinical procedures with a lesser chair side time, increase confidence and experience. Treatment with laser also helps to overcome the disadvantages associated with the conventional dental procedures. Though at present we are unable to use lasers for all dental procedures, hopefully with more studies and better understanding of them in the near future the applications for dental lasers will expand and a greater numbers of dentists in future will use the technology to provide their patients with precise treatment that may minimize pain and recovery time.

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Conflicts of interest: None

Table 1 Some common laser types available for the use in dentistry[7]

Laser type	Construction	Wavelength(s)	Delivery system(s)
Argon	Gas laser	488, 515nm	Optical fibre
KTP	Solid state	532nm	Optical fibre
Helium-neon	Gas laser	633nm	Optical fibre
Diode	Semiconductor	635, 670, 810, 830,980nm	Optical fibre
Nd:YAG	Solid state	1064nm	Optical fibre
Er,Cr:YSGG	Solid state	2780nm	Optical fibre
Er:YAG	Solid state	2940nm	Optical fibre, waveguide, articulated arm
CO_2	Gas laser	9600, 10600nm	Waveguide, articulated arm

Table 2 Photothermal effects of laser light on the target tissue sites[1]

Tissue temperature (°C)	Effect on the targeted tissue
37–50	Hyperthermia
60–70	Coagulation, protein denaturation (blanched appearance of tissues)
70–80	Welded appearance of tissues (layers adhere to each other due to stickiness of collagen caused by helical unfolding & intertwining)
100–150	Vaporization leading to tissue ablation
>200	Carbonization

Table 3 Dental lasers & their Chromophores[6]

Laser	Chromophores
Argon	Hemoglobin, melanin, resin catalyst
HeNe	Melanin
Diode	Melanin, water
Nd:YAG	Melanin, water, dentin
Ho:YAG	Water, dentin
ErCr:YSGG	Water, hydroxyapatite
Er:YAG	Water, hydroxyapatite
CO_2	Hydroxyapatite, water

References

1. Coluzzi, D.J. 2004. Fundamentals of dental lasers: science and instruments. Dental Clinics of North America, 48(4):751-70.

2. Shajahan, P.A., Kumar, P.R., Hariprasad, A., Mathew, J., Shaji, A.P. and Ahammed, M.F. 2015. Lasers: The Magic Wand in Esthetic Dentistry!! *Journal of International Oral Health*, 7(6):119-121.
3. A. Einstein. 1916. The quantum theory of radiation: 47-62.
4. Maiman T. 1960. Stimulated optical radiation in ruby. Nature, 187:493–4.
5. Green, J. Weiss, A. and Stern, A. 2011. Lasers and radiofrequency devices in dentistry. Dental Clinics, 55(3):585-597.
6. Parker, S. 2007. Introduction, history of lasers and laser light production. British dental journal, 202(1):21-31.
7. Walsh, L.J. 2003. The current status of laser applications in dentistry. Australian dental journal, 48(3):146-155.
8. Flax, H.D. 2011. Soft and hard tissue management using lasers in esthetic restoration. Dental Clinics, 55(2):383-402.
9. Convissar, R.A., 2004. The biologic rationale for the use of lasers in dentistry. Dental Clinics, 48(4):771-794.
10. Parker, S., 2007. Lasers and soft tissue: periodontal therapy. *British dental journal*, 202(6): 309-315.
11. Kotlow, L.A., 2004. Lasers in pediatric dentistry. Dental Clinics of North America, 48(4):889-922.
12. Kravitz, N.D. and Kusnoto, B., 2008. Soft-tissue lasers in orthodontics: an overview. American journal of orthodontics and dentofacialorthopedics, 133(4):110-114.
13. Gracco, A., Tracey, S., Lombardo, L. and Siciliani, G., 2011. Soft tissue laser in orthodontics. Progress in orthodontics, 12(1):66-72.
14. Parker, S., 2004. The use of lasers in fixed prosthodontics. Dental Clinics of North America, 48(4):971-98.
15. Weiner, G.P., 2004. Laser dentistry practice management. Dental Clinics of North America, 48(4):1105-26.
16. Luthra, R.P. and Gupta, R., 2011. Lasers In Prosthetic Dentistry: A Review. *Indian Journal of Dental Sciences*, 3(3):41-44.
17. Piccione, P.J., 2004. Dental laser safety. Dental Clinics of North America, 48(4):795-807.

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