JMSCR Volume||2||Issue||5||Page 1235-1241||May 2014

2014

www.jmscr.igmpublication.org Impact Factor-1.1147
ISSN (e)-2347-176x

Journal Of Medical Science And Clinical Research
IGM Publication
An Official Publication Of IGM Publication

Lasers in Dentistry

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Abstract

Lasers were introduced in dentistry with the hope that it can overcome the drawbacks of the conventional methods and its use has increased considerably since its introduction. The aim of this review is to describe lasers and its applications in the field of dentistry.

Key words: laser, tissue interaction, soft tissue lasers, hard tissue lasers, application, safety

INTRODUCTION

The word 'LASER' is an acronym for Light Amplification by Stimulated Emission of Radiation. [1]

Light

Light is a form of electromagnetic energy that behaves both as a wave and a particle. The basic unit of this energy is called a photon. [2]

Ordinary light,usually appearing white, is the sum of the many colors of the visible spectrum-violet,blue,green,orange and red. Laser energy is one specific color, a property called monochromacity. This energy also possesses a property known as coherency,meaning that the waves produced in the laser instrument are all in phase with one another and have identical shapes when plotted on a graph.

The beam is collimated (the rays are parallel) within the laser instrument. However, a lens system in the aperture focuses the beam into a delivery system and the emitted energy can either continue as a constant diameter or will diverge at a specific angle.

The wave of photons moving at the speed of Light can be defined by two properties.

The first is amplitude , which is the total height of the wave oscillation from the top of the peak to zero line on a vertical axis .

Importance: This is an indication of the amount of intensity in the wave. The larger the amplitude, the greater the amount of useful work that can be performed.

The second property is wavelength , which is the distance between any two corresponding points on the wave on the horizontal axis.

Importance: This is the physical size of the wave which is important on how it interacts with tissue. Wavelength is generally measured in meters but dental lasers use a smaller unit either a micron or nanometer

Stimulated Emission

Quantum theory was introduced by German physicist Max Planck in 1990 which was further conceptualized as relating to atomic architecture by Neils Bohr [3] ,a physicist from Denmark. When a quantum ,the smallest unit of energy is absorbed by the electrons of an atom or molecules, a brief excitation occurs. The quantum is soon released into a resting state, a process called spontaneous emission. The emitted energy packet was previously described as a photon. In 1916, Albert Einstein [4] theorized that an additional photon traveling in the field of the excited atom that has the same excitation energy level would result in a release of two quanta or coherent wave of two photons, a phenomenon he termed stimulated emission.

Amplification

If this process were to continue, more atoms would be energized, and more identical photons would be emitted and further propagation of this stimulators wave would result. At some point a population inverse occurs meaning that a majority of the atoms of the active medium are in the elevated rather than the resting state. A pumping mechanism offering a constant supply of energy is necessary to maintain the excitation.

The photons are reflected back and forth within the active medium to further enhance stimulated emission and successive phases through the active medium increase the power and ultimately collimate the photon beam. This is called amplification .

Radiation

The laser energy produced by the laser are specific form of radiation or electromagnetic energy. The electromagnetic spectrum is the entire collection of wave energy ranging from gamma rays whose wavelength are about 10 meters, to radio waves whose wavelength can be thousands of meters. All available dental laser devices have emission wavelength of approximately 0.5 microns or 500 nano meters to 10.6 microns or 10,600 nano meters. That places them either in the visible or invisible portion of non-ionizing portion of the electromagnetic spectrum. The dividing line between the ionizing, cellular DNA mutagenic portion of the spectrum and the non-ionizing portion is on the junction of ultraviolet and visible violet light. Thus all dental lasers emit either a visible light wavelength or an invisible infrared light wavelength in the portion of that non-ionizing spectrum called thermal radiation.

LASER TISSUE INTERACTION

Lasers interact with the tissues in four ways

1. Reflection-which is the beam redirecting itself off the surface having no effects on the target tissue.
2. Transmission-the laser energy is directed through the tissue with no effect on target tissue.
3. Scattering-results in weakening of the intended energy and possibly producing no useful biological effect. Scattering of laser beam can cause heat transfer to the adjacent tissue adjacent to surgical site.
4. Absorption- can cause coagulation, protein denaturation, bacterial inactivation. [1]

ACTION OF LASERS ON DENTAL TISSUES

The action of lasers on dental hard and soft tissues depend on the absorption of laser by tissue chromphore (water, apatite minerals and various pigmented substances) within the target tissue.

Mechanism:

1. Photothermal ablation: this occurs with high powered lasers when used to vaporize or coagulate tissue through absorption in a major tissue component.
2. Photomechanical ablation: disruption of tissue due to a range of phenomena including shock wave formation, cavitations.
3. Photochemical effects: using light sensitive substances to treat conditions such as cancer.

SOFT TISSUE LASERS

Soft tissue lasers enable safe and effective removal of short tissue and can be used for procedures that are done using a scalpel.

The soft tissue lasers available are

1. Carbon di oxide laser
2. Nd:YAG lasers
3. Argon lasers
4. H:YAG lasers
5. Er, Cr:YSGG lasers
6. Diode lasers

The diode lasers whose wavelength ranges from 810-980 nm are mostly used.

Applications

1. Gingival contouring
2. Leveling
3. Troughing
4. Gingivectomy
5. Exposure of unerupted teeth
6. Operculectomy
7. Frenectomy
8. Soft tissue incision
9. Treatment of apthous ulcer [5]

Advantages

Soft tissue lasers result in minimum or no bleeding, effective wound healing, and do not affect the surrounding tissue. There is no vibration and kills bacteria in deep cavity.

Disadvantages

Although diode lasers with 810-980 nm is used in the sulcular debridement , it can only be used in shallow pockets as it causes charring effects in deep pockets. ([5], [6]) A study by M.R.Dickson in 1991 [7] on the interaction of lasers in soft tissues of cadavers concluded that in cellular tissues the damage is approximately 20 micro meter. K.Gorharkhay in 1999 [8] investigated the incision characteristics of soft tissue damage by a diode laser(810 nm). Due to excellent coagulation ability the diode laser can be used instead of the scalpel and conventional electro surgical unit.

Further studies on laser tissue interaction with a continuous wave 3 micro meter fibres by Mark C.Pierre in 2000 [9] demonstrated the acute and precise removal of soft tissues. In vitro study of soft tissue effects of microsecond pulsed carbon di oxide laser parameters during soft tissue incision and sulcular debridement by Vaderhobli RM in 2010 [10] achieved minimal lateral and deep coagulation in reasonable amount of time.

HARD TISSUE LASERS

The hard tissue laser provides a constantly sterile instrument that produces a minimal inflammatory response and hence minimal pain. They are safer than a scalpel or an air turbine as the zone of cutting is confined to the focal spot of 1-2mm. Erbium lasers are currently used.

Advantages

Ability to selectively ablate carious dental tissue

Allows for minimally invasive restorative treatment in early caries

Reduced pulpal temperature rise

Cavity sterilization

Pain reduction properties: laser light raises the point at which the C pain fibres trigger an impulse making it possible to do some procedure under topical anesthetic only.

Healing properties: the light stimulates the mitochondria in the cells adjacent to the abated area to heal 50% faster with a minimum of scar tissue as the wound heals by primary intention

Applications

Paedodontics

Hard tissue lasers can equal pain free, injection free, drill free dentistry for kids. Pulps can be cauterized and roots can be disinfected.

Orthodontics

It is used in crown lengthening where it can uncover a tooth by removing the gingiva with a bloodless field and minimal after pain. The laser can soften orthodontic bonding cement which can then be scraped away with a scaler reducing the damage to surface enamel. [11]

Restorative dentistry and Endodontics

a) **Cavity preparation**

The Er:YAG laser was tested for preparing dental hard tissues for the first time in 1998. It was successfully used to prepare holes in enamel and dentin with low 'fluencies' [energy(mJ)/unit area(cm)].

Even without water cooling (Burkes et al 1992) [12] the prepared cavities showed no cracks and low or no charring while the mean temperature rise of the pulp cavity was about 4.3 C (Rechmann at al 1998) [13] . Clinically cavity preparation in enamel results in ablation craters with white chalky appearance on the surface of the crater (Tokonabe et al 1999). [14] In dentin the cavity margins are sharp and dentinal tubules open without a smear layer.

b) **Caries removal**

Carious material contains a higher water content compared with surrounding healthy dental hard tissues. Consequently, the ablation efficiency of caries is greater than for healthy tissues.

It was found out that the Er:YAG laser abated carious dentin effectively with minimal thermal damage to the surrounding intact dentin (Aoki and Ishikawa at al 1998). [15]

c) **Restoration removal**

The Er:Yag lasers is capable of removing composite resin and glass ionomer (Dostalova et al 1998, Gimbel 2000) ([16], [17])Lasers should not be used to ablate amalgam restorations because of potential release of mercury vapor.

Er:YAG laser is incapable of removing gold crowns, cast restorations and ceramic materials because of the low absorption of these materials and reflection of laser light (Keller et al 1998). [18]

d) **Etching**

Laser etching can be used as an alternative to acid etching of enamel and dentin. The Er:YAG laser produces micro explosions during hard tissue ablation that result in microscopic and macroscopic irregularities . These make the enamel surface micro retentive and provide adhesion without acid etching. However, adhesion to dental hard tissues after Er:YAG laser etching is inferior to conventional acid etching (Martinez-Insua et al 2000, Ceballos et al 2001).([19], [20])

e) **Caries prevention**

The possibility of using lasers to prevent caries have been explored (Hossain et al 2000, Apel at al 2003). ([21], [22])

It is suggested that laser irradiation of dental hard tissues modifies the calcium to phosphate ratio, reduces the carbonate to phosphorus ratio and leads to the formation of more stable and less acid soluble compounds.

SAFETY

Laser safety is regulated according to American National Standard Institute (ANSI) Z136 safety standards. Diode lasers can cause retinal burns and cataracts. Erbium lasers risk corneal burns and infrared cataracts. A discernable danger zone should be created around the surgical bay. Immediately after the procedure , the patient should rinse and gently massage the area with a soft bristle tooth brush. [23]

CONCLUSION

Although lasers cannot replace all the conventional procedures in dentistry, it's use enables some procedures to be performed differently than the conventional procedure and its development in the field of dentistry continues to expand further enabling greater patient care.

REFERENCES

1) Coluzzi DJ,DDS Portola Valley California . Fundamentals of lasers in dentistry:Basic science,Tissue interaction and Instrumentation, J Laser2008;16 (Spec Issue):4-10
2) The photonics dictionary:46th ed. Pitsfield,Masse Laurin Publishing ,2000

3) Bohr N. The theory of spectra and atomic constitution. Three essays. Cambridge: Cambridge University Press 1992.
4) Einstein A. Strahlungs-emission and absorption nach der quanten theorie. Verh Dtsch Phys Ges 1916;18:318-323. German.
5) Mitchell A. Lomke. Clinical Applications of Dental Laser . General dentistry. 2009
6) Raymond J. Volley, Soft tissue lasers and procedures, Academy of dental therapeutics and Stomatology. December 2010.
7) M.R.Dickson, Studies of Er-YAG laser interaction with soft tissue laser, Lasers in Medical Science, June 1991, Volume 6, Issue 2, pp 125-131
8) Gorharkhay K, Effects on Oral Soft Tissue Produced by a Diode Laser In Vitro, Lasers in Surgery and Medicine 25:401-406 (1999)
9) M.C.Pierce , Laser-tissue interaction with a continuous wave 3-mcm fibre lasers: preliminary studies with soft tissue, Laser Surg Med ; 2000;26(5):491-5
10) Vadherhobli , In Vitro study of soft tissue effects of microsecond pulsed CO(2) laser parameters during soft tissue incision and sulcular debridement . Lasers Surg Med 2010 Mar;42(3):257-63.doi:10-1002/lsm.20888
11) Oliver Harman, Lasers in General Practice:Hard tissue lasers, Dentistry. Vol 2, 2010.
12) Burkes EJ, Hoke J, Gomes E and Wolbarsht M (1992). Wet versus dry enamel ablation by Er: YAG laser. J Prosthet Dent, 67: 847-851.
13) Rechmann P, Goldin DS and Hennig T (1998). Er: YAG lasers in dentistry: an overview. SPIE, 3248
14) Tokonabe H, Kouji R, Watanabe H, Nakamura Y and Matsumoto K (1999). Morphological changes of human teeth with Er: YAG laser irradiation. J Clin Laser Med Surg, 17(1): 7-12.
15) Aoki A, Ishikawa I, Yamada T, Otsuki M, Watanabe H, Tagami J, Ando Y and Yamamoto H (1998). Comparison between Er: YAG laser and conventional technique for root caries treatment in nitro. J Dent Res, 6: 1404-1414.
16) Dostalova T, Jelinkova H, Kucerova H, Krejsa O, Hamal K, Kubelka J and Prochazka S (1998). Noncontact Er: YAG Laser Ablation: Clinical Evaluation. J Clin Laser Med Surg, 16(5): 273- 282.
17) Gimbel CB (2000). Hard tissue laser procedures. Dental Clinics of North America, 44(4): 931-953.
18) Keller U, Hibst R, Geurtsen W, Schilke R, Heidemann D, Klaiber B and Raab WHM (1998). Erbium: YAG laser application in caries therapy. Evaluation of patient perception and acceptance. J Dent, 26: 649-656.
19) Martinez-Insua A, Dominguez LS, Rivera FG and Santana-Penin UA (2000).

Differences in bonding to acid-etched or Er: YAG – laser – treated enamel and dentine surfaces. J Prosthet Dent, 84: 280-288.

20) Ceballos L, Osorio R, Toledano M and Marshall GW (2001). Microleakage of composite restorations after acid or Er: YAG laser cavity treatment. Dental Materials, 17: 340-346.
21) Hossain M, Nakamura Y, Kimura Y, Yamada Y, Ito M and Matsumoto K (2000). Caries-Preventive Effect of Er: YAG Laser Irradiation with or without Water Mist. J Clin Laser Med Surg, 18(2): 61-65.
22) Apel C, Schafer C and Gutknecht N (2003). Demineralization of Er: YAG and Er,Cr: YSGG Laser-Prepared Enamel Cavities in vitro. Caries Res, 37: 34-37.
23) Miserendino LJ , Pick RM. Lasers in dentistry Chicago :Quintessence Publishing 1995