Available online at www.elixirpublishers.com (Elixir International Journal)

Dentistry

Elixir Dentistry 87 (2015) 35664-35669

ISSN: 2229-712X

Lasers in Periodontics

Harmandeep Singh*, Navkiran Kaur and Ashish Verma

Department of Periodontology and Oral Implantology, Sri Guru Ram Das Institute of Dental Sciences and Research, Amritsar 143001 India.

ARTICLE INFO

Article history:

Received: 08 August 2015;
Received in revised form: 01 October 2015;
Accepted: 07 October 2015;

Keywords

Lasers,
Surgical Lasers,
Periodontal therapy.

ABSTRACT

The use of the laser in its relationship to dentistry is a new tool. Surgical lasers have been used in medicine for over a decade in the surgical specialties of Otolaryngology, dermatology, plastic surgery, gynecology, ophthalmology, neurosurgery, urology, thoracic and cardiovascular surgery, gastrointestinal surgery, orthopaedics and most recently in oral and maxillofacial surgery. Recently lasers have been recommended as an alternative or adjunctive therapy in the control and treatment of periodontally diseased root surface. Lasers commonly used in dentistry are CO2, Nd:YAG, Ho:YAG, Er: YAG, Er,Cr:YSGG, Nd:YAP, GaAs (diode) and argon .The present article aims at providing an overview of basic principles and various types of lasers used in periodontal therapy. An Abstract is required for every paper; it should succinctly summarize the reason for the work, the main findings, and the conclusions of the study. The abstract should be no longer than 100 words. Do not include artwork, tables, elaborate equations or references to other parts of the paper or to the reference listing at the end. The reason is that the Abstract should be understandable in itself to be suitable for storage in textual information retrieval systems.

Introduction

Laser is an acronym for Light Amplification by Stimulated Emission of Radiation. The rapid development of laser technology, as well as a better understanding of laser interaction with biological tissues, has widened the spectrum of possible applications of lasers in dentistry. The numerous current and potential uses of lasers in dentistry have been identified that involve the treatment of soft tissue and modification of hard tooth structures. Today the laser is used in the scanners at the grocery store, in compact disc players, as a pointer for lectures and above all in the medical and dental field.

Currently, numerous laser systems are available for dental use. Neodymium-doped:Yittrium- Aluminium-Garnet (Nd:YAG), carbon dioxide (CO2) and semiconductor diode lasers have already been approved by the United States Food and Drug Administration for soft tissue treatment in oral cavity[1]. For any application it is important to select the correct wavelength for absorption of the energy and prevention of side effects from heat generation.

The use of lasers for periodontal treatment becomes more complicated because the periodontium consists of both hard and soft tissues. The use of lasers within the periodontal pocket has become a topic of much interest and is a promising field in periodontal therapy.

Historical background

The use of lasers 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 [1].It was in the late 1940's that scientists did extensive work to realize a practical device based on the principle of stimulated emission. In 1955, Gordon and others were the first to demonstrate the stimulated emission of microwaves within the electromagnetic spectrum. In 1957,

American physicist Townes and Schawlow first amplified microwave frequencies for application in microwave communication systems and the acronym MASER (microwave amplification by stimulated emission of radiation) came into use. In 1958, they discussed extending the maser principle to the optical portion of the electromagnetic field, hence, LASER (light amplification by the stimulated emission of radiation) was introduced.[2] .In 1960, the first working laser, a pulsed ruby instrument, was built by Theodore Maiman in Hughes Research Laboratories.

Physics of laser

Lasers are devices that produce intense beam of light which is monochromatic, coherent and highly collimated. Lasers can concentrate light energy and exert a strong effect, targeting tissue at an energy level that is much lower than that of natural light.

All laser devices have the following components:

- Optical cavity or resonator
- An active medium or lasant.
- Two mirrors at each end of the optical cavity.
- Excitation source.

Generation of laser energy

An active lasing medium, which can be a solid, liquid, or gas, is enclosed within a laser cavity bounded by two parallel reflectors (mirrors). High-energy radiation is pumped into the active medium by means of a pump source[3]. The pump source is energy generally provided by an intense optical or electrical discharge. The energy from the pump source is absorbed by the active medium until the majority of atoms, ions, or molecules are raised to their upper energy state. This is a condition known as a population inversion and is a necessary condition to generate laser light. The light is repeatedly bounced between the reflector mirrors at either end. This will stimulate the emission of even more photons (amplification) in that axial direction. Light travelling in other directions escapes the cavity and is lost as heat. One of the mirrors is only partially reflective, enabling some of the light to escape the cavity as a beam of laser light. Weaker light that is not optically pumped to the threshold is constantly leaking through the less reflective mirror.

Tele:
E-mail addresses: harman617@gmail.com

Properties of laser

There are several important properties of laser light that distinguish it from white light. These singular properties of laser light that makes it useful for surgery are monochromaticity, directionality, coherence, collimation and brightness[4].

Monochromaticity

Lasers emit light that is monochromatic or specifically a single wavelength. The monochromaticity is that property of the laser radiation which describes its spectral distribution correlated with its intensity. So, in the laser beam case the maximum intensity is obtained at a given wavelength around which the most part of the radiation is emitted; the most part of the beam energy is accumulated at a small number of wavelengths around the wavelength of the maximum intensity.

Directionality

There is little divergence of the laser as it exits the laser device, and the beam can travel a considerable distance with very little movement away from parallelism. Most gas or solid-state lasers emit laser beams with a divergence angle of approximately a milliradian. It describes qualitatively the property of the laser radiation to remain concentrated at long distances along and around a given direction; the divergence describes the same properties quantitatively.

Coherence

Coherence is a property of laser light in which light waves produced in the instrument are all the same. There are two types of coherence of laser light, longitudinal and transverse. The longitudinal type of coherence represents a time or temporal coherence along the longitudinal beam axis, whereas transverse or spatial coherence refers to coherence across the beam.

Collimation

It is defined as the phenomenon in which the laser beam has specific spatial boundaries, which in turn ensures that there is a constant size and shape of the beam emitted from the laser cavity. A dental X-ray machine produces radiation with this property. Coherence thus causes the collimation of a laser beam over extremely large distances and allows the beam to accept extremely fine focusing.

Brightness

Laser light is distinguished from white light by its property of brightness. In qualitative terms, the brightness of the laser radiation is described by the laser light beam intensity which is given by the number of photons emitted outside the laser optical cavity, reported to the unit surface of the laser beam cross section.The laser beam brightness is due to its directivity coupled with its power and with the monochromaticity of the radiation.

Laser energy and tissue temperature

The thermal effect of laser energy on tissue primarily revolves around the water content of tissue and the temperature rise of the tissue. The observed effects at various temperatures are as follows[5]: (Table 1)

Interactions of laser with tissues

Laser light can have four different interactions with the target tissue, depending on the optical properties of that tissue. Dental structures have complex composition, and these four phenomena occur together in some degree relative to each other[6] :

Absorption

The amount of energy that is absorbed by the tissue depends on the tissue characteristics, such as pigmentation and water content, and on the laser wavelength and emission mode. Dental structures have different amounts of water content by weight. A ranking from lowest to highest would show enamel (with 2% to 3%), dentin, bone, calculus, caries, and soft tissue (at about 70%).

Transmission: directly through the tissue with no effect on the target tissue, the inverse of absorption. This effect is highly dependent on the wavelength of laser light . The depth of the focused laser beam varies with the speed of movement and the power density.

Reflection

Which is the beam redirecting itself off of the surface, having no effect on the target tissue. A caries-detecting laser device uses the reflected light to measure the degree of sound tooth structure. The laser beam generally becomes more divergent as the distance from the handpiece increases. However, the beam from some lasers can have adequate energy at distances over 3 m. This reflection can be dangerous because the energy is directed to an unintentional target such as the eyes; this is a major safety concern for laser operation.

Scattering

Scattering of the laser beam could cause heat transfer to the tissue adjacent to the surgical site, and unwanted damage could occur. However a beam deflected in different directions is useful in facilitating the curing of composite resin or in covering a broad area.

Classification of lasers

Lasers classification is based on different criteria

Classification based on laser safety

This classification of lasers is based chiefly on the potential of the primary laser beam or the reflected beam to cause biologic damage to the eyes or skin. There are four general classes of lasers; the higher the classification number, the greater the potential hazard.

- Class I: A Class I laser is considered safe based upon current medical knowledge.
- Class II: A Class II laser or laser system is defined as operating in the visible region (400-700nm). These lasers are not inherently safe.
- Class III
  - o Class III a: A Class IIIA laser emits higher levels of radiation and requires more stringent precautions than those necessary for Class II laser products.
  - o Class III b: Class IIIB lasers can emit either invisible or visible radiation and direct viewing is hazardous to the eye.
- Class IV: Class IV lasers are high-power lasers that pose a serious potential for injury of the eye and skin and require that users follow specific safety precautions and wear laser protective eyewear.[3]

Classification based on laser medium

- Excimer lasers : Argon fluoride (ArF)
  Xenon chloride (XeCl)
- Gas laser : Argon
  Helim Neon (HeNe)
  Carbon dioxide (CO_2)
- Diode lasers :Indium Gallium Arsenide Phosphorous (InGaAsP)
  Gallium aluminium Arsenide (GaAlAs)
  Gallium Arsenide (GaAs)
  Indium Gallium Arsenide (InGaAs)
- Solid state lasers : Nd:YAG
  Ho:YAG
  Er,Cr:YSGG
  Er:YSGG
  Er:YAG

Frequency double alexandrite potassium titanium Phosphate (KTP).

Table 1. Effects of tissue temperature

Tissue temperature	Observed effects
37-50	Hyperthermia, bacterial invasion
>60	Coagulation, protein denaturation
70-90	Welding
100-150	Vaporization, ablation
>200	Carbonization

Table 2. Properties of Argon Lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
488-514 nm	Gated continuous	Flexible fibre or optic system	Absorbed by pigmented tissues	Noncontact or contact mode

Table 3. Properties of co_2 lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
10.64 µm	Gated or continuous	Hollow wave guide/ articulated arm	High absorption coefficient in water	Beam focused at1-2mm from target surface

Table 4. Properties of Nd : YAG lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
1.064 µm	pulsed	Flexible fibre optic system	Absorbed by pigmented tissues. Low absorption coefficient in water	Surface contact required

Table 5. Properties of Nd:YAG lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
2.94 µm	Free running pulsed	Flexible Fibre optic system/Hollow wave guide	Highly absorbed in water and hydroxyapatite	Surface contact required

Table 6. Properties of Er Cr: YSGG lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
2.78 µm	Free running pulsed	Sapphire crystal inserts of varying diameters	High absorption coefficient in water	Surface contact required

Table 7. Properties of Diode lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
635-950 nm	Gated or continuous	Flexible fiberoptic system	Absorbed by pigmented tissues. Low absorption coefficient in water.	Surface contact required

Table 8. Properties of Ho :YAG lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
2.1 µm	Free running pulsed	Flexible fiberoptic system	High absorption coefficient in water	Surface contact required

Table 9. Properties of He -Ne lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
632.8nm	Continuous	Flexible fiberoptic system	Absorbed by pigmented tissues.	Non contact

Table 10. Properties of KTP lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
532nm	Pulsed	Flexible fiberoptic system	Absorbed by pigmented tissues.	Surface contact required

Table 11. Properties of Excimer lasers

Wavelength	Wave form	Delivery tip	Tissue reaction	Contact
ArF laser -193nm XeCl laser – 308nm	Pulsed	Flexible quartz glass fibres	Absorbed by pigmented tissues.	Surface contact Required

Classification based on emission modes

- Continuous wave : Carbon dioxide
  Argon
  Diode lasers
- Gated pulsed wave : Nd:YAG laser
  Carbon dioxide laser
  Diode lasers
  KTP laser
- Free pulsed wave : Er:YAG laser
  Er,Cr:YSGG laser
  Er:YSGG laser

Laser wavelengths in dentistry

Lasers used in dentistry vary from the ultraviolet light (100-400nm) to the infra red spectrum (750nm-1000nm). The visible spectrum lies between these two wavelengths (400-750nm and infrared). [7]

The various lasers used are as follows:

I. Argon laser: (Table 2)

II. Carbon dioxide laser : CO2 laser (Table 3)

III Neodymium: Yttrium-Aluminium-Garnet laser : Nd:YAG laser (Table 4)

IV.Erbium family : Erbium: Yttrium-Aluminium-Garnet laser: Er:YAG laser (Table 5)

V.Erbium: Chromium: Yttrium:Selenium-Gallium-Garnet laser : Er,Cr:YSGG laser : (Table 6)

VI. Diode lasers: (Table 7)

VII.Indium Gallium Arsenide Phosphorous (InGaAsP) : Red Gallium Aluminium arsenide (GaAlAs) : Red-infrared

Gallium Arsenide (GaAs): Infrared

Holmium: Yttrium-Aluminium-Garnet laser : Ho:YAG laser (Table 8)

VIII..Helium neon laser : He-Ne laser (Table 9)

IX..Frequency double alexandrite potassium titanium phosphate laser -KTP laser (Table 10)

X..Excimer lasers : (Table 11)

Advantages of laser treatment in periodontics

- Effective and efficient soft and hard tissue ablation with a greater hemostasis,
- Bactericidal effect,
- Minimal wound contraction,
- Minimal collateral damages with reduced use of local analgesia.
- Minimal mechanical trauma. Disadvantages of laser treatment in periodontics
- Expensive mode of treatment.
- Laser irradiation can interact with tissues even in the non-contact mode, which means that laser beams may reach the patient's eye and other tissues surrounding the target in the oral cavity.
- Lack of training of practitioners may lead to improper usage of the equipment and thus inadvertent irradiation of the teeth and periodontal pockets can damage the tooth surfaces and attachment apparatus.
- Laser treatment may result in destruction of the attachment apparatus at the bottom of the pockets.[2]

Applications of lasers used in dentistry

Lasers used in dentistry cover a broad range of procedures, from the diagnosis of caries or cancer to soft tissue and hard tissue procedures.

The present applications of laser in dentistry are as follows [8]

Diagnosis

- Detection of pulp vitality [9]
- Optical coherence tomography[13],[14]
- Biopsy incision and excision
- Laser fluorescence

Hard Tissue Applications

- Operative dentistry
- Treatment of dentinal hypersensitivity
- Endodontics
- Sterilization [18]
- Crown lengthening procedure[19]

Aesthetic Dentistry

- Composite resin restoration.
- Bleaching.
- Aesthetic contouring.
- Laser scar revision.
- Clinical crown lengthening

Soft Tissue Applications

- Endodontics

o Pulp capping

o Pulpotomy and pulpectomy[20]

Oral and maxillofacial surgery

o Incisional and excisional procedures[15],[16],[17]

o Vestibuloplasty[21]

o Operculectomy[22]

Prosthodontics

o Alveoloplasty

o Surgical treatment of tori and exostosis

Implantology

o Implant soft tissue surgery

o Treatment of perimplantitis[23].

o Second stage implants therapy for uncovering the submerged implant.

Periodontics

o Laser scaling [27]

o De-epithelialization: CO2 and Er:YAG lasers are used[25],[26].

o Gingivectomy and gingivoplasty

o Frenectomy

o Bacterial decontamination[24]

Laser Induced Analgesia

Clinical applications in periodontics

De epithelialisation

CO2 laser can be used to retard the downward growth of epithelium. The absorption of CO2 energy by gingival tissue can be controlled in such a manner that vaporization of the intracellular fluid occurs, leading to the disruption of the entire cell. Because the interaction between the CO2 wavelength and gingival tissues is shallow in depth (0.1–0.3 mm), it results in less wound contraction and a reduced inflammatory response.

Laser assisted flap surgery

CO2 laser is used in flap surgery for de epithelialization of flap. This procedure permits the connective tissue to form new attachment onto the smooth root surface. This wavelength surgical technique shows tremendous potential in periodontal regenerative surgery.

When sites treated by laser de-epithelialization combined with osseous grafts are compared with nonlased sites in split-mouth experimental designs, the CO2 sites show better gain of clinical attachment level and increased osseous fill of infrabony defects.

Calculus removal and root conditioning

Nd:YAG laser can be used in detachment of calculus from the root surface. After laser irradiation, removal of remaining calculus by curettes is facilitated. As subgingival calculus is originally dark in color, the Nd:YAG laser has the advantage of being absorbed well into subgingival calculus. Use of higher energy levels may ablate calculus more efficiently.

Periodontal pocket treatment

Pocket curettage with laser as an adjunct to conventional mechanical root surface treatment has been increasingly performed by general practitioners because of its ease of use. The use of Nd:YAG laser in periodontal pockets results in decrease in microbial levels of periodontal pathogens. Laser assisted removal of pocket lining epithelium in periodontal pockets, without causing necrosis or carbonization of the underlying connective tissue. Because of its high penetrability, the possible thermal effects of this laser on tissues lying below the irradiated area, such as dental pulp or bone tissue, is occasionally a matter of concern during periodontal treatment.

Root conditioning

The Er:YAG laser does not cause carbonization of the irradiated root surface, but it has been demonstrated that the ablated surface becomes chalky after drying due to micro-irregularities on the lased surface. The surface of Er:YAG laser-treated calculus under water coolant has been reported to exhibit a micro-irregular appearance without melting and carbonization, likely due to the effects of the mechanical ablation.

Peri-implantitis

This Er:YAG laser seemed to be capable of effectively removing bacterial deposits from either smooth or rough titanium implants without damaging their surfaces.

Gingivectomy and frenectomy

Due to its property of resulting in hemostasis, Diode laser is widely used in the surgical treatment of high frenal attachments (frenectomy) and other soft tissue surgeries, including gingivectomy, gingivoplasty.

Removal of soft tissue

Argon, diode, and Nd:YAG lasers are useful for pigmented and vascular lesions, whereas nonpigmented lesions are more effectively removed by an Erbium or CO2 laser due to their wavelength absorption in the water of the lesions. The CO2 laser has been used for the following oral soft tissue procedures: removal of benign tumors and lesions, fibromas, papillomas, nicotinic stomatitis, verruca vulgaris, lichen planus, inflammatory papillary hyperplasias, hyperkeratotic lesions, and soft tissue tuberosity reductions. Operculums and distal soft tissues can also be removed with the CO2 laser.

Laser safety

Regardless of the eye protection, a practitioner never should look directly at the laser beam[11].

• As the normal surgical masks do not filter the laser plume, a new generation of laser surgical masks are now available that will filter 0.1µm particles.

• Contact with tooth enamel should be avoided during CO2 and Er:YAG laser emission, as they easily cause melting or ablation.

• Laser safety also includes the protection of tooth structure adjacent to the impact site.

• Fire hazard associated with class IV lasers take many forms.

o Lasers should not be used in the presence of explosive gases.

o Alcohol should be kept away from the site of the laser.

o Oxygen supplementation should be minimized during laser surgery.

o Use only wet or fire-retardant materials in the operative field.

• When general anaesthesia is performed, a red rubber and/or a metallically coated tube should be employed rather than the usual PVC intubation tube.

• Use of wet gauze packs maybe occasionally useful for the protection of the oral tissues surrounding the surgical site from the accidental beam impact.

• Adequate high beam evacuation is necessary to capture laser plume, which is a biohazard[12].

Conclusion

The future of laser use in periodontal procedure is bright. As techniques are improved and devices are refined further, lasers will become an important part of the armamentarium in periodontal treatment. Research is currently underway using lasers in different surgical procedures for periodontal ligament and bone regeneration as well as in the field of implantology.When using proper diagnostic and treatment-planning protocols and with proper energy settings and techniques, the laser elevates the level of conservative care that can be provided to patients.

References

1. Lee D. Application of laser in periodontics: a new approach in periodontal treatment: the Hong Kong Medical Diary 2007;12 :23-25. VOL.12 NO.10 OCTOBER 2007
2. Pick RM, Colvard MD, Current status of lasers in soft tissue dental surgery. J Periodontol 1993; 64: 589-602.
3. Coluzzi DJ , Convissar RA, lasers in Clinical Dentistry. Dental Clinics of North America 2004; 48: 751-1127.
4. Pascu ML. Laser physics elements to consider for low level laser therapy. Laser Therapy 2001;13 :114-125
5. White JM, Goodis HE, Kudler JJ, Tran KT. Thermal laser effects on intraoral soft tissue, teeth and bone in vitro. Third International Congress on Lasers in Dentistry. Salt Lake City: University of Utah; 1992.
6. Frank F. Laser light and tissue biophysical aspects of medical laser application. SPIE Lasers Med 1989; 1353:37–45.
7. Bains VK, Gupta S, Bains R . Lasers in periodontics: an overview.J Oral Health Comm Dent 2010; 4 :29-34.
8. George R. Laser in dentistry- review. Int. J Dent. Clinics 2009; :10-13
9. Samraj RV ,Indira R ,Srinivasan MR, Kumar A. Endodontology 2003; 15 :14-19
10. Zysk AM, Nguyen FT, Oldenburg AL , Marks DL ,Boppart SA. Optical coherence tomography: A review of clinical development from bench to bedside. Journal of Biomedical Optics 2007; September/October 12(5) : 051403
11. United states department of labor, occupational safety and health administration. Hazard of laser surgery smoke. Hazard information bulletin. Washington, DC. Department of Labor 1988.
12. Smith JF, editor. Laser safety guide. 9th edition. Orlando (FL): Laser Institue of America.
13. Zysk AM, Nguyen FT, Oldenburg AL , Marks DL ,Boppart SA. Optical coherence tomography: A review of clinical development from bench to bedside. Journal of Biomedical Optics 2007 ;12 : 051403-1-21
14. Lim H, Jiang Y, Wang Y, Huang Y, and Chen Z. Ultrasonic resolution optical coherence tomography with a fiber laser source at 1 µm. OPTICS LETTERS. 2005 ; 30 : 1171-1173
15. Suter V , Altermatt H, Sendi P , Mtertraux G, Bornstein M. CO2 and diode laser for excisional biopsies of orl mucosal lesions. Schweiz Monatsschr Zahnmed 2010; 120 :664-671
16. Goharkay K, Moritz A, Wilder- Smith P, Schoop U, Kluger W, Jakolitsch S, et al. Effects on oral soft tissue produced by a diode laser in vitro. Lasers Surg Med.1999;25 :401-6
17. Frank Y.W. Yung,The use of an Er:YAG laser in periodontal surgery: Clinical cases with long- term follow .Laser Dent 2009;17: 13-20
18. Leco-Berrocal MI, Martinez- Gonzalez JM, Donado – Rodriguez M, Lopez- Carriches C. Sterilizing effects of the

Erbium : Yag laser upon dental structures: An in vitro study. Med Oral Patol Oral Cir Buccal 2006; 11:158-61.
19. Lee EA. Laser – Assisted Crown Lengthening Procedures in the Esthetic Zone: Contemporary Guidelines and Techniques. CONTEMPORARY ESTHETICS 2007 ; MARCH :42-49
20. Golpayegani MV, Ansari G , Tadayon N, Shams S , Mir M. Low–Level Laser Therapy for Pulpotomy Treatment of Primary Molars. Journal of Dentistry, 2009; 6: 168-174
21. Kovacevska G, Tomov G, Baychev P, Kovacevski A, Andreevska V. Er:YAG Laser Assisted Vestibuloplasty: A Case Report. Journal of Surgery 2013; 1: 59-62.
22. Sabra SMM. Laser-Aided for Pericoronal Bacterial Load Reduction and Operculectomy Healing of Impacted Mandibular Molar, Taif, KSA. World Appl. Sci. J 2014; 29 (1): 01-08.
23. Schwarz F, Aoki A, Sculean A , Becker J. The impact of laser application on periodontal and peri-implant wound healing Periodontology 2000, 2009; 51: 79-108
24. Kreisler M, Kohnen W, Marinello C, Gotz H, Duschner H, Jansen B, d_Hoedt B. Bactericidal effect of the Er:YAG laser on dental implant surfaces: an in vitro study. J Periodontol 2002; 73: 1292–1298.
25. Rossmann JA, Gottlieb S, Koudelka BM , McQuade MJ, Effects of CO2 laser irradiation on gingival. J Periodontol 1987; 58: 423-425.
26. Centty GI, Blank LW, Levy BA, Romberg E , Barnes DM. Carbon dioxide laser for de-epithelialization of periodontal flaps J Periodontol 1997; 68 : 763-769.
27. Misra V, Mehrotra KK, Dixit J , Maitra SC. Effect of a carbon di-oxide laser on periodontally involved root surfaces. J Periodontol 1999; 70: 1046–1052.