Laser Application in Periodontics

Seyyed Amir Seyyedi[1], Ehsan Khashabi[2], Farnaz Falaki[3]

[1]Department of Oral Medicine, Urmia University of Medical Sciences, Urmia, Iran.
[2]Department of Periodontics, Urmia University of Medical Sciences,Urmia, Iran
[3]Department of Oral Medicines, Mashhad University of Medical Sciences, Mashhad, Iran

Abstract

Introduction: The use of lasers for treatment has become a common phenomenon in the medical field. Currently, numerous laser systems are available for dental use. The use of lasers for periodontal treatment becomes more complicated because the periodontium consists of both hard and soft tissues.
Methods: Related articles were gathered and selected carefully and reviewed. Among the many lasers available, high power lasers such as Carbon Dioxide Laser (CO_2), Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) and diode lasers can be used in periodontics. The use of these lasers is limited to gingivectomy, frenectomy and similar soft tissue procedures including the removal of melanin pigmentation of gingiva. Recently, Erbium: Yttrium Aluminium Garnet(Er:YAG) and Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er,Cr:YSGG) lasers are used for scaling, root debridement, cutting, shaving, contouring and resection of oral osseous tissues.
Results: In addition to their surgical applications, low-level lasers such as Er:YAG laser irradiation promotes osteoblast proliferation showing higher and favorable bone tissue regeneration. These findings suggest faster bone tissue healing following periodontal and peri-implant low level laser therapy.
Conclusion: Advantages of laser treatment in periodontics are effective and efficient soft and hard tissue ablation with a greater hemostasis, bactericidal effect, minimal wound contraction, faster bone tissue healing, minimal collateral damages along with reduced use of local analgesia.
Keywords: laser; periodontitis; implant

Please cite this article as follows:
Seyyedi SA, Khashabi E , Falaki F. Laser application in periodontics : J Lasers Med Sci 2012; 3(1):26-32

*Corresponding Author: Seyyed Amir Seyyedi, DDS.MSc.; Dept. of Oral Medicine, Faculty of Dentistry Urmia University of Medical Sciences, Urmia, Iran. Tel: +98-9143408762; Fax: +98-4413470517; Email: seyyediamir@yahoo.com

Introduction

Maybe no one ever imagined that the magic beam shown in the Star Wars movies could someday treat their gums! The history of the lasers has been very exciting as their nowadays application modalities. In 1960, Maiman introduced “light amplification by stimulated emission of radiation” (LASER) using Einstein’s theories about the stimulated emission (1). Since then, different lasers, such as diode, CO_2, Nd: YAG, Er: YAG, and Er, Cr: YSGG have been developed and within a few years have been used in dentistry (2,3). Unfortunately despite this relatively long history, there is no consensus in the profession about the advantages or disadvantages of the lasers. This might be due to the variety that exists in the research design and personal experiences, and the low evidence-based approach seen in the dental literature. In this article we have tried to review the current knowledge and experiences on the lasers and their application in periodontics and implant dentistry. There are two different ways that a laser beam can be delivered: a flexible hollow waveguide, or tube that has an interior mirror finish, or glass fiber optic cable. The main effect of laser energy is photothermal. The final response of the target tissue depends on the degree of temperature increase and the tissue water content. Optical properties of periodontium such as pigmentation, water content, mineral content, heat capacity and latent heats of transformation can also determine the clinical application alongside specific wavelength, heat conduction and dissipation, and the amount of tissue congestion.(4).

There are various lasers available that can be used in periodontics. From a point of view they can be divided either to the soft tissue lasers or soft and hard tissue lasers. Neodymium-doped:Yittrium-Aluminium-Garnet (Nd:YAG), carbon dioxide (CO_2) and semiconductor diode lasers can be categorized as the soft tissue group while erbium family lasers are capable of performance in both hard and soft tissues(4,5). Since the periodontium consists of both hard and soft tissues, the erbium group lasers seem more beneficial for periodontal applications. A summary of different laser wavelengths and their properties can be seen in table 1.

Table 1. Current lasers specification and application

Laser type	Wave-length (in nm)	Wave form	Delivery system	Clinical applications in periodontics
Carbondioxide (CO_2) laser	10600	Gated or continuous	Hollow waveguide/ articulated arm	Soft tissue incision and ablation; aphtus ulcer treatment, analgesia, melanin pigment removal, treatment of dentine hypersensitivity subgingival curettage; biopsy; decontamination of implant
Neodymium: Yttrium-aluminium-garnet (Nd:YAG) laser	1064	Pulsed	Flexible fiberoptic system	Soft tissue incision and ablation; subgingival curettage; bacterial elimination, pulpotomy, root canal disinfection, sulcular debridement, caries removal, aphtus ulcer treatment, analgesia, melanin pigment removal, treatment of dentine hypersensitivity
Erbium: yttrium-aluminium-garnet (Er:YAG) laser	2940	Free running pulsed	Flexible fiberoptic system or Hollow waveguide	Soft tissue incision and ablation; subgingival curettage; scaling; root conditioning; osteoplasty and ostectomy; degranulation and decontamination of implants, analgesia, melanin and metal pigment removal, treatment of dentine hypersensitivity
Erbium, Chromium: yttrium-selenium-gallium-garnet (Er,Cr;YSGG) laser	2780	Free running pulsed	Air-cooled fiberoptic/ handpiece	Soft tissue incision and ablation; subgingival curettage; scaling of root surfaces; osteoplasty and ostectomy, dentin and enamel surface modification
Argon (Ar) laser	488 and 514	Gated or continuous	Flexible fiberoptic system	Soft tissue incision and ablation, composite curing, tooth withening, sulcular debridement for periodontium and peri-implant tissues
Indium-gallium-arsenide-phosphide; Gallium-aluminium-arsenide; Gallium-InGaAsP, GaAlAs, GaAs(diode) laser	635 to 950	Gated or continuous	Flexible fiberoptic system	Soft tissue incision and ablation, caries and calculus detection subgingival curettage; Soft tissue incision and ablation; subgingival curettage; bacterial elimination, pulpotomy, root canal disinfection, sulcular debridement, caries removal, aphtus ulcer treatment, analgesia, melanin pigment removal, treatment of dentine hypersensitivity

Non-surgical Periodontal Therapy

Dental plaque is known as the principal etiologic factor for the inflammatory periodontal disease; therefore, it is evident that treatment of the disease is dependent upon how much the plaque and its retentive factors are being removed. Traditional mechanical therapy using hand instruments have shown limitation in accessing the dental biofilm and calculus, because of their bulk and shape. Lasers have been proposed to solve this limitation as the beam can reach the deepest pockets and grooves. The advantage of the laser in treating inflammatory conditions like periodontitis has been also attributed to their host immuno-modulatory effects. All lasers have thermal effects. Many periodontopathogens are susceptible to this thermal range as research has shown that they are deactivated in 50 c° (6). Laser mediated coagulation and inflamed tissue removal takes place in 60 c° (7). Lasers offer clear field views in periodontal surgeries and sub-gingival scaling and curettage that are advantageous over the conventional treatments. Patients are also more comfortable with intermittent laser activation sound rather than high-pitch sound of ultrasonic devices. Pain is lesser in laser application and the need for anesthesia is reduced in procedures such as sub-gingival scaling (4,8,9). Photodynamic therapy is another important application of a low power laser that enables the laser to indirectly decontaminate the periodontal pocket by activation of a photo-sensitizer agent, thus potentiating the bactericidal effect of laser. Soft tissue thermolysis and bacterial decontamination can be done by a variety of lasers such as argon (10) (488 nm, 514 nm), diode laser (11) (800-830 nm, 980 nm) and Nd: YAG (12-14) (1064 nm), but these lasers are unsuitable for calculus removal because of low surface thermal absorption. Erbium family lasers including Er:YAG and Erbium-Chromium doped: Yittrium-Selenium-Gallium-Garnet (Er, Cr: YSGG) have shown very promising results for scaling, since they are capable to ablate both hard and soft tissues (4). In an interesting research, Schwartz et al have shown that clinical parameters of periodontitis have improved significantly after a year in both groups treated either with Er: YAG laser alone, or combined with manual scaling and root planning without significant differences (15). Aoki has shown that subgingival calculus removal by Er: YAG is not associated with root surface thermal increase (16). In addition, it has been shown that the other member of the Erbium family (Er, Cr: YSGG) has an intense bactericidal effect on the putative periodontal pathogens, such as P. gingivalis and A. actinomycetemcomitans (17). Selective removal of supra-gingival and sub-gingival calculus and dental plaque without ablating underlying hard tissue with frequency doubled Alexandrite laser (337 nm) is a promising application that needs further studies (18). Periodontal inflammation and congestion provide an environment that is ideal for soft lasers such as argon that reduces bacterial load and coagulate since the tissues are hemoglobin pigmented and full of interstitial water.

Periodontal Surgery

Lasers are beneficial in reducing traditional surgical problems such as bleeding, reduced vision, pain, scarring, suturing, bacteremia, long healing period and wound contraction. They will also result in higher patient acceptance, since no or little anesthesia is required. Periodontal surgery can be divided to soft surgery and simultaneous soft and hard surgery. Potential bone damage has been always a concern in periodontal surgery using lasers. CO_2, diode, and ND:YAG are traditionally known as soft tissue laser since their deep penetration makes them ideal for applications such as frenectomy, frenotomy, gingival curettage, depigmentation, aphtus treatment and leukoplakia management Figures 1.

CO_2 laser have been used successfully for gingivectomy and plastic reshaping of the gingiva. It has been shown that application of the CO_2 impedes pocket epithelium growth considerably more, compared to the control group. Crespi et al. showed that CO_2 laser is enable to successfully condition the root surface (19).

Hard tissue lasers can be applied to both hard and soft tissues. In one study, using Fourier Transformation Infrared Spectra it was shown that toxic byproducts are produced after application of Er: YAG laser without water coolant (20) and CO_2 laser irradiation (21,22) that results in delayed healing (3).

A key factor in determining how the laser will interact with the underlying tissues is the depth of penetration. Some lasers penetrate deeply and the thermal effects are seen in deep tissues while

Figure 1. Use of co_2 Laser Therapy for Treatment of oral Leukoplakia; before and after ablation

others provide a surface ablation. CO_2, Er: YAG, and Er, Cr: YSGG laser radiation primarily affects superficial layers of the tissues and hence are advantageous, since the risk of damage to the underlying tissues are minimized. However, deeply penetrating Nd: YAG and diode lasers produce thicker coagulation areas on radiated surfaces (16,21,23), have a greater heat production ability and hence are used similar to electrosurgical procedures (21). Finkbeiner has suggested the application of argon laser in soft tissue welding and soldering compared to traditional wound closure means, such as sutures and tissue adhesives (24).

There have been conflicting opinions about the quality of wound healing after laser periodontal surgeries. Some find it faster with little or no scar, while others believe lasers impede normal wound healing by producing vaster area of necrosis. Recently it has been shown that low-level laser therapy using gallium, aluminium arsenide GaAIAs radiation, influences periodontal ligaments fibroblasts positively, and as a result has a beneficial effect on periodontal wound healing (25).

Figures 2 and 3 show two cases of gingival wart and excisional biopsy of an exophytic lesion in hard palate

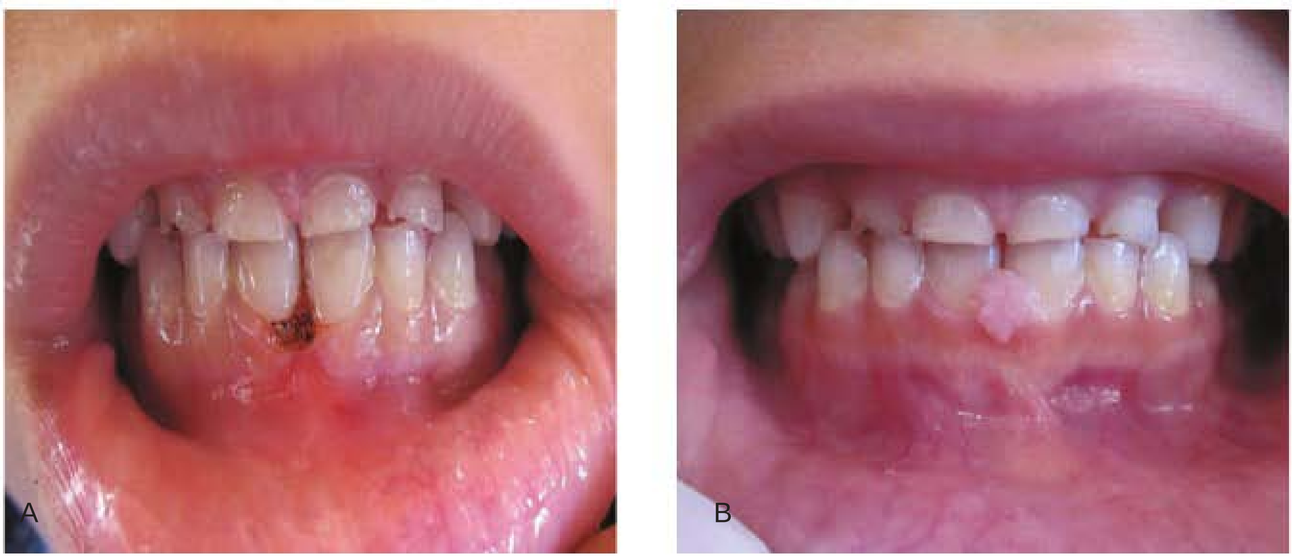

Figure 2. Gingival wart; before and after ablation by co_2 laser

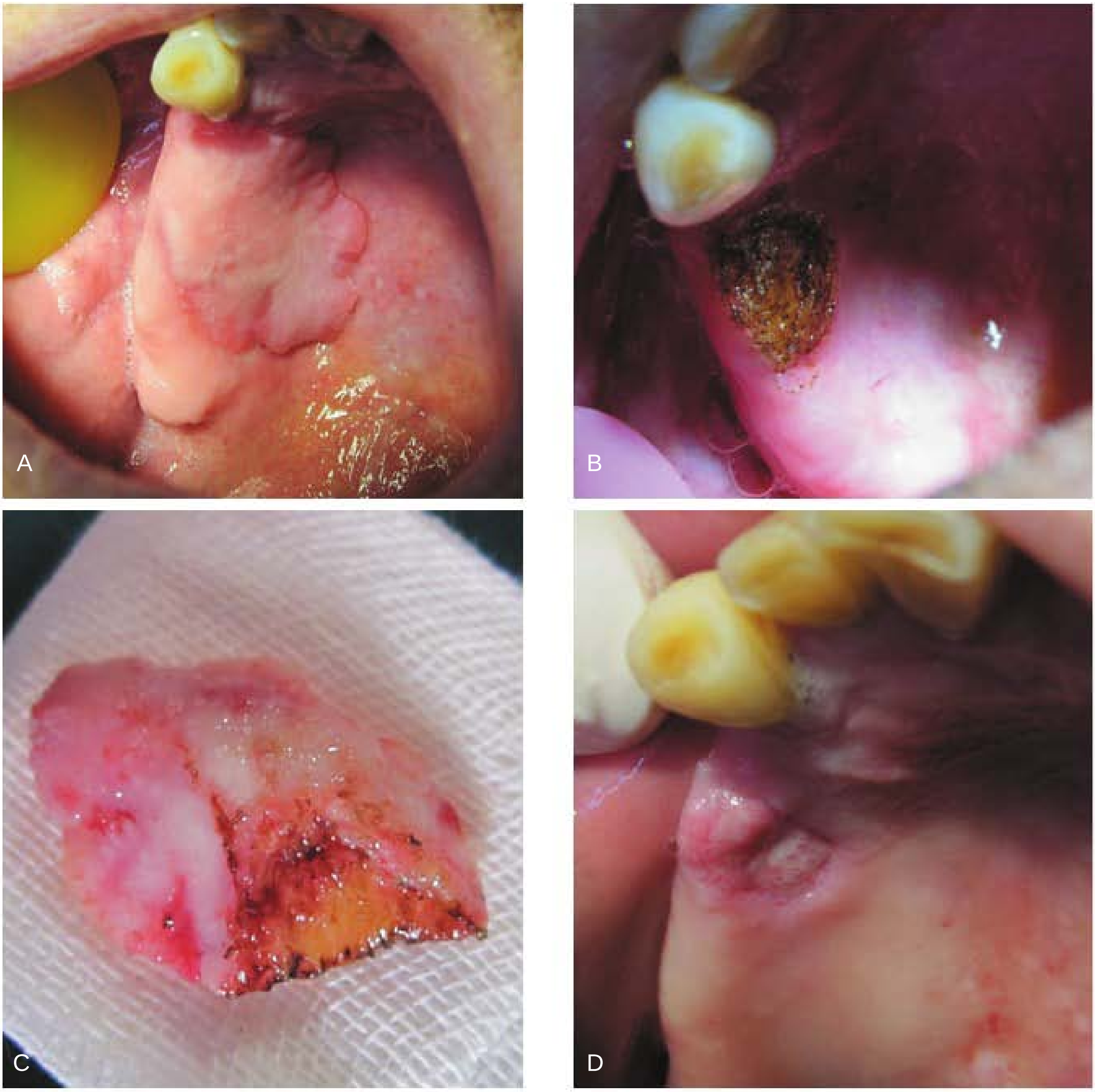

Figure 3. Excisional biopsy of fibroepitelial hyperplasia in hard palate by co_2 laser

Implant Dentistry

The most common application of lasers in the implant dentistry is soft tissue removal during second stage implant exposure. Lasers offer instant coagulation of the small blood vessels providing a clear field, and the patient benefits from less pain and swelling. There are some reports about treatment of peri-implantitis with lasers. Treatment of peri-implantitis includes thorough debridement of implant surface without damaging either the bone or implant. This means that many traditional instruments used to treat periodontitis, such as ultrasonic devices cannot be applied for peri-implantitis treatment, as there are limitations in their size and effectiveness in the hard access areas such as furcations and deep pockets. Likewise ND:YAG lasers are contraindicated as they change implant surface. Lasers are beneficial in peri-implantitis management. Bactericidal properties and delicate debridement of microscopic fins and recesses are advantageous over traditional hand instruments. The CO_2, diode, and Er: YAG lasers appear to be safe for treating peri-implant diseases. It has been reported that CO_2 and Er: YAG lasers application does not alter osteoblast attachment rate (26). Er: YAG seems more suitable, since it can be used on both implant surface and bone, although this laser may potentially alter the implant surface morphology, if inappropriate settings are used.

Recently, first stage implant surgery has been performed with Er: YAG with no complication and apparently faster osteointegration, and it has been hypnotized that lower mechanical stress is produced in bone compared to traditional drill osteotomy (27-29).

Advantages and Drawbacks

Maybe the most important drawback of laser application is the lack of support from the evidence based and controlled studies. Unfortunately, most of the knowledge about the clinical applications of lasers has been through case reports, case series, or inappropriately controlled studies.

Periodontal microsurgery can definitely benefit from lasers because of its fine and delicate beam that enables the clinician to delicately detect any calculus or tissue conditions and minimizes trauma to the gingival tissue, bone and implant resulting in less tissue shrinkage, pain and edema. It has been reported that soft tissue surgery with CO_2 laser reduces the surgery time to one forth. On the other hand, one can not overlook the disadvantage of loss of tactile sense when using soft tissue lasers, such as CO_2, diode, and Er:YAG.

Unlike antibiotics, lasers render their bactericidal properties without common side effects such as bacterial resistance, gastrointestinal complications and drug interactions, and can thus be used in childhood and pregnancy without limitations.

On the other hand, laser generators are still expensive and space consuming.

Conclusion

Plaque and calculus removal, coagulation, faster tissue ablation and healing, no or minimal pain, no or few sutures, instant sterilization, little tissue shrinkage and depigmentation are main factors favoring laser application in periodontics. On the other side, cost, safety issues, technical complexities, and lack of evidence-based studies about therapeutic effects and efficiencies are drawbacks of laser treatment. The erbium group lasers appear to be the choice laser in periodontics. More controlled studies are needed before lasers can become a routine tool in periodontal procedures.

References

1. Maiman TH. Stimulated optical radiation in ruby. Nature 1960;187: 493-4.
2. Goldman L, Hornby P, Meyer R, Goldman B. Impact of the laser on dental caries. Nature 1964; 203: 417.
3. Stern RH, Sognnaes RF. Laser beam effect on dental hard tissues. J South Calif Dent Assoc. 1965 Jan;33:17-9.
4. Cobb CM. Lasers in periodontics: a review of literature. J Periodontol 2006;77(4):545-564.
5. Ishikawa I, Aoki A, Takasaki AA. Potential applications of Erbium:YAG laser in periodontics. J Periodont Res 2004;39(4):275-285.
6. Russell AD. Lethal effects of heat on bacterial physiology and structure. Sci Prog 2003;86(Pt 1-2):115-37.
7. Knappe V, Frank F, Rohde E. Principles of lasers and biophotonic effects. Photomed Laser Surg 2004; 22(5):411-7.
8. Wigdor H, Walsh JT Jr, Featherstone JDB, Virsuri S, Fried D, Waldvogel JL. Lasers in dentistry. Lasers Surg Med 1995;16(2):103-133.
9. Luomanen M, Meurman JH, Lehto VP. Extracellular matrix in healing CO_2 laser incision wound. J Oral Pathol 1987;16(6):322-331.
10. Finkbeiner RL. The results of 1328 periodontal pockets treated with the argon laser: selective pocket thermolysis. J Clin Laser Med Surg 1995;13(4):237-281.
11. Moritz A, Schoop U, Goharkhay K, Schauer P, Doertbudak O, Wernisch J. Treatment of periodontal pockets with a diode laser. Lasers Surg Med 1998;22(5):302-311.
12. Neil ME, Mellonig JT. Clinical efficacy of the Nd:YAG laser for combination periodontitis therapy. Pract Periodontics Aesthet Dent 1997;9(6 Suppl):1-5.
13. Liu CM, Hou LT, Wong MY, Lan WH. Comparison of Nd: YAG laser versus scaling and root planing in periodontal therapy. J Periodontol 1999;70(11):1276-1282.
14. Raffetto N, Gutierrez T. Lasers in periodontal therapy, a five-year retrospective. J Calif Dent Hyg Assoc 2001; 16:17-20.
15. Schwarz F, Sculean A, Georg T, Reich E. Periodontal treatment with an Er:YAG laser compare to scaling and root planing. A controlled clinical study. J Periodontol 2001; 72(3): 361-7.
16. Aoki A, Sasaki K, Watanabe H, Ishikawa I. Lasers in

non-surgical periodontal therapy. Periodontology 2000 2004;36:59-97.

17. Ando Y, Aoki A, Watanabe H, Ishikawa I. Bactericidal effect of erbium YAG laser on periodontopathic bacteria. Lasers Surg Med 1996;19(2):190-200.

18. Rechmann P, Henning TH. Selective ablation of sub- and supragingival calculus with a frequency-doubled Alexandrite laser. Proc SPIE 1995;2394: 203-210.

19. Crespi R, Barone A, Covani U. Histologic evaluation of three methods of periodontal root surface treatment in humans. J Periodontol 2005:76(3):476-81.

20. Sasaki KM, Aoki A, Masuno H, Ichinose S, Yamada S, Ishikawa I. Compositional analysis of root cementum and dentine after ER:YAG laser irradiation compared with CO_2 laser and intact roots using Fourier transformed infrared spectroscopy. J Periodontal Res 2002;37(1):50-59.

21. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi Y. Application of lasers in periodontics: true innovation or myth? Periodontol 2000 2009;50:90-126.

22. Sasaki KM, Aoki A, Ichinose S, Yoshino T, Yamada S, Ishikawa I. Scanning electron microscopy and Fourier transformed infrared spectroscopy analysis of bone removal using Er:YAG and CO_2 lasers. J Periodontol 2002;73(6):643-652.

23. White JM, Goodis HE, Rose CL. Use of pulsed Nd;YAG laser for intraoral soft tissue surgery. Lasers Surg Med 1991;11(5):455-461.

24. Finkbeiner RL. Free autogenous soft tissue graft with argon laser. J Clin Laser Med Surg. 1995 Feb;13(1):1-5.

25. Schwarz F, Aoki A, Sculean A, Becker J. The impact of laser application on periodontal and peri-implant wound healing. Periodontol 2000 2009;51:79-108.

26. Romanos G, Crespi R, Barone A, Covani U. Osteoblast attachment on titanium disks after laser irradiation. Int J Oral Maxillofac Implants 2006;21(2):232-6

27. El Montaser MA, Devlin H, Sloan P, Dickinson MR. Pattern of healing of calvarial bone in the rat following application of the erbium-YAG laser. Lasers Surg Med 1997;21(3):255-261.

28. Kesler G, Romanos G, Koren R. Use of Er:YAG laser to improve osseointegration of titanium alloy implants—a comparison of bone healing. Int J Oral Maxillofac Implants 2006;21(3):375-9.

29. Schwarz F, Olivier W, Herten M, Sager M, Chaker A, Becker J. Influence of implant bed preparation using an Er:YAG laser on the osseointegration of titanium implants: a histomorphometrical study in dogs. J Oral Rehabil 2007;34(4):273-281.