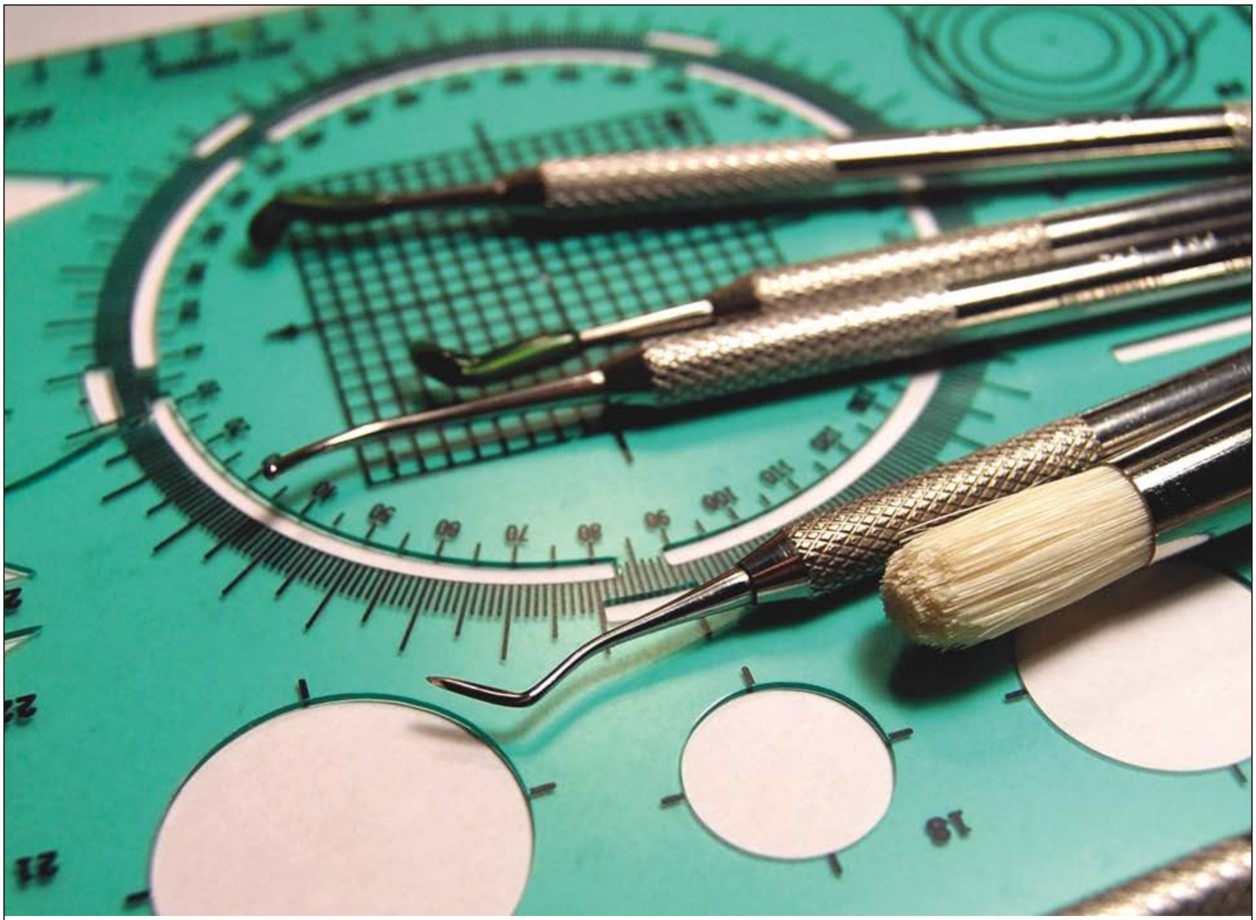

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Lasers in Periodontics-A Review

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ABSTRACT

Lasers were introduced into the field of clinical dentistry with the hope of overcoming some of the drawbacks posed by the conventional methods of dental procedures. Since, its first experiment for dental application in the 1960s, the use of laser has increased rapidly in the last couple of decades. At present, wide varieties of procedures are carried out using lasers. The aim of this study is to describe the current status of application of lasers in the treatment of periodontal diseases.

Key words: Lasers, periodontology, periodontitis

INTRODUCTION

In the past 100 years there has been extensive development of the mechanical cutting devices used in dentistry. However, while considerable progress has been made in this area of mechanical cutting, dental patients are still afraid of the noise and vibration produced by the mechanical action of the air turbine or ultrasonic scalers. From the end of the 20th century until now, there has been a continuous upsurge in the development of laser-based dental devices based on photo-mechanical interactions. In fact, the French postal service recently released a memorial stamp showing the five greatest innovations of science in the 20th century. One of them was the laser (Ishikawa *et al.*, 2009).

The development of laser energy as a modality in the management of periodontitis and related problems is an ongoing and exciting discipline. The myriad interactions that make various laser wavelengths useful as therapeutic tools are just beginning to be explored. The number of different wavelengths used for soft tissue and root surface procedures is growing rapidly as a better understanding of the interactions of the coherent light energy with the oral target tissues is developed. The evolution of laser therapy for soft tissue manipulation and as an adjuvant in the management of infectious aspects of periodontitis is progressing quite rapidly. Dentistry has entered an era of high technology, the dental lasers offer the clinician not only a window, but a door into this high tech arena; The aim of this review is to determine the state of the science regarding the application of lasers to common oral soft tissue problems, root surface detoxification and the treatment of chronic periodontitis.

History: It has been nearly 50 years since the first laser device was produced. In the medical field, lasers have been successfully used since the mid-1960s for precise photocoagulation of the retina. Thus, ophthalmologists were the pioneers of laser application. Since then, lasers have been used in many industrial and scientific applications, which, in turn, has spurred new and innovative developments in this area.

Based on albert einstein's theory of spontaneous and stimulated emission of radiation, Maiman (1960) developed the first laser prototype. Thus, the ruby laser was created. Shortly, thereafter, Snitzer (1961) published the prototype for the ND: YAG laser. The first application of a laser to dental tissue was reported by Goldman *et al.* (1964) and it was suggested by Myers and Myers (1985) that Nd: YAG laser could be used for oral soft tissue surgery. Myers (1989) published the first article on the pulsed Nd: YAG laser in periodontal surgery. However, it was found that those lasers designed for soft tissue removal were not suitable for the treatment of dental hard tissues. The Nd:YAG laser was not appropriate for dental caries treatment because of its difficulty in cutting hard tissues as well as its deeply penetrating effects causing potential pulpal damage (Wigdor *et al.*, 1993). Cracking with fragmentation and carbonization of the cavity, in addition to melting and resolidification, were constantly observed in enamel and/or dentin as a result of use of the CO_2 laser. Thus, the first dental lasers approved by the US Food and Drug Administration, namely the CO_2, the Nd:YAG and the diode lasers, were accepted for use only for oral soft tissue procedures in periodontics. As periodontal tissues are composed of not only soft but also hard tissues and the previous laser systems had not been shown to be effective for the treatment of hard tissues, new laser systems needed to be developed. There has since been an enormous body of work using different types of lasers which include CO_2 lasers, Argon lasers, Erbium, Holmium and excimer YAG lasers and Diodes.

How does a laser work?: Laser is an acronym standing for light amplification by stimulated emission of Radiations. All laser devices have the following components:

- A laser medium that can be solid, liquid or gas. This medium determines the wavelength of the light emitted from the laser and the laser is named after the medium
- Optical cavity/laser tube: consists of two minors, one fully reflective and the other partially transmissive located at either end of the optical cavity
- Some form of external power source: Excites or pumps the atoms in the laser medium to higher energy levels

Atoms in the excited state spontaneously emit photons of light which bounce back and forth between the two mirrors in the laser tube. A they bounce within the laser tube, they strike other atoms, stimulating more spontaneous emissions. Photons of energy of the same wavelength and frequency escape through the transmissive mirror as the laser beam, which can be focused.

As an extremely small intense beam of energy that has the ability to vaporize, coagulated and cut if a lens is placed in front of the beam (Fig. 1).

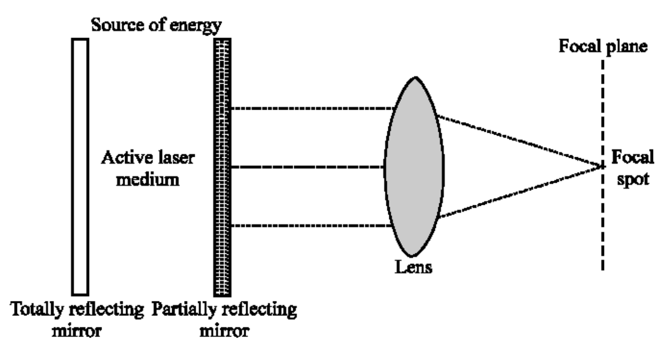

Fig. 1: Component diagram from a laser

Importance of wavelength: Lasers commonly used in dentistry consist of a variety of wavelengths delivered as either a continuous, pulsed (gated), or running pulse form (Table 1) (Fig. 2). The laser beam interacts with a target material and may get absorbed, reflected or scattered (Fig. 3). In the case of biologic tissues, the laser energy is absorbed by target surface tissues and will only exhibit scattering in cases of deep tissue penetration. Depending on various parameters, the absorbed energy can result in simple warming, coagulation, or excision and incison through tissue vaporization. Variable parameters affecting energy absorption include: emission wavelength, Power (watts), wave form (i.e., continuous or pulsed), pulse duration, energy/pulse, energy density, duration of exposure, peak power of pulse, angulation of energy delivery tip to the target surface and optical properties of the tissue (e.g., Factors such as pigmentation, water content, mineral content etc.).

Each wavelength of laser energy is absorbed to a grater or lesser degree in water, pigment, or hydroxyapatite given the diversity of available wavelengths, the prudent clinician should first determine the specific clinical treatment goals and then select the laser best suited to achieve the desired end points (Table 2).

Types of lasers: The following is a closer look at each laser type:

The CO_2/Carbon dioxide laser: Patel *et al.* (1964) were the first to develop Carbon dioxide laser.

Common abbreviation : CO_2
Wavelength : 10.6 µm
Wave form : Continuous/gated

Table 1: Type and wavelength of lasers

Laser type	Wavelength (nm)	Color
Excimer lasers		
Argon fluoride (ArF)	193	Ultraviolet
Xenon chloride (XeCl)	308	Ultraviolet
Gas lasers		
Argon	488	Blue
	514	Blue-green
Helium neon (HeNe)	637	Red
Carbon dioxide (CO_2)	10,600	Infrared
Diode lasers		
Indium gallium arsenide phosphorus (InGaAsP)	655	Red
Gallium aluminum arsenide (GaAlAs)	670-830	Red-infrared
Gallium arsenide (GaAs)	840	Infrared
Indium gallium arsenide (InGaAs)	980	Infrared
Solid state lasers		
Frequency-doubled alexandrite	337	Ultraviolet
Potassium titanyl phosphate (KTP)	532	Green
Neodymium: YAG (Nd:YAG)	1,064	Infrared
Holmium: YAG (Ho:YAG)	2,100	Infrared
Erbium, chromium:YSGG (Er,Cr:YSGG)	2,780	Infrared
Erbium: YSGG (Er:YSGG)	2,790	Infrared
Erbium: YAG (Er:YAG)	2,940	Infrared

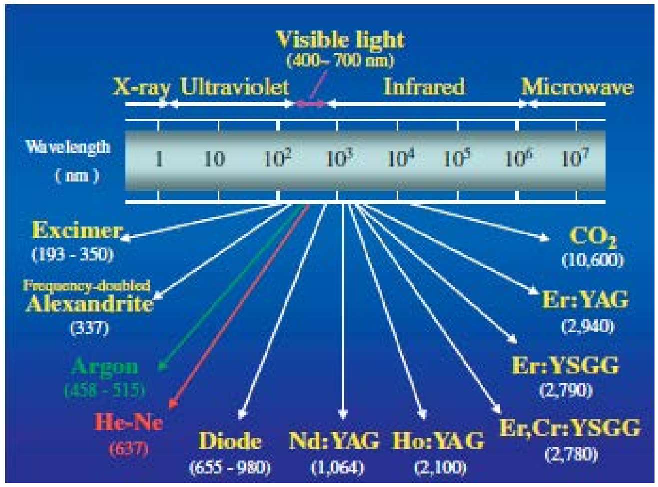

Fig. 2: Electromagnetic spectrum and wavelengths of lasers

Table 2: Current and potential applications of lasers in dentistry

Laser type	Current/potential dental application
Excimer lasers	
Argon Fluoride (ArF)	Hard tissue ablation, dental calculus removal
Xenon Chloride (XeCl)	
Gas lasers	
Argon (Ar)	Curing of composite materials, tooth whitening, intraoral soft tissue surgery, sulcular debridement (subgingival curettage in periodontitis and peri-implantitis)
Helium neon (HeNe)	Analgesia, treatment of dentin hypersensitivity, a phthous ulcer treatment
Carbon dioxide (CO_2)	Intraoral and implant soft tissue surgery, aphthous ulcer treatment, removal of gingival melanin pigmentation, treatment of dentin hypersensitivity, analgesia
Diode lasers	
Indium gallium arsenide Phosphorus (InGaAsP)	Caries and calculus detection
Galium Aluminum Arsenide (GaAlAs) and Galium Arsenide (GaAs)	Intraoral general and implant soft tissue surgery, sulcular debridement (subgingival curettage in periodontitis and peri-implantitis), analgesia, Treatment of dentin hypersensitivity, pulpotomy, root canal disinfection, aphthous ulcer treatment, removal of gingival melanin pigmentation
Solid state lasers	
Frequency-doubled Alexandrite	Selective ablation of dental plaque and calculus
Neodymium:YAG (Nd:YAG)	Intraoral soft tissue surgery, sulcular debridement (subgingival curettage in periodontitis), analgesia, treatment of dentin hypersensitivity, pulpotomy, root canal disinfection, Removal of enamel caries, aphthous ulcer treatment, removal of gingival melanin pigmentation
Erbium group Erbium:YAG (Er:YAG), Erbium:YSGG (Er:YSGG), Erbium,chromium:YSGG (Er, Cr:YSGG)	Caries removal and cavity preparation, modification of enamel and dentin surfaces, Intraoral general and implant soft tissue surgery, sulcular debridement (subgingival curettage in periodontitis and peri-implantitis), scaling of root surfaces, osseous surgery, treatment of dentin hypersensitivity, analgesia, pulpotomy, root canal treatment and disinfection, aphthous ulcer treatment, removal of gingival melanin/metal-tattoo pigmentation

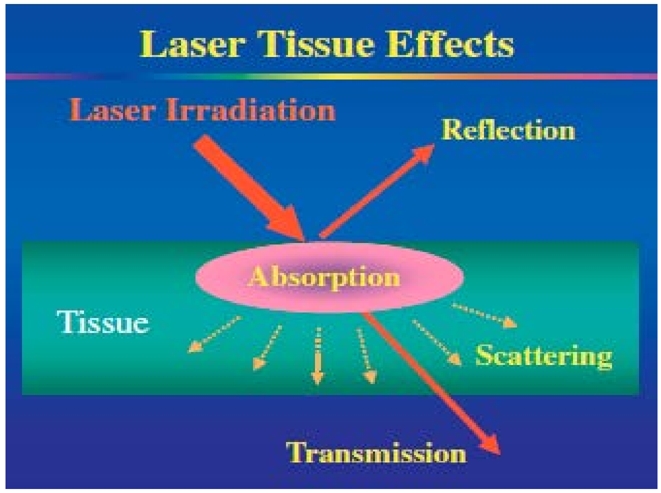

Fig. 3: Effect of laser irradiation on tissues

Delivery tip	:	Hollow wave guide; beam focused when 1 to 2 mm from target surface
Reported-periodontal applications	:	Soft tissue incision and ablation; subgingival curettage
Tissue reaction	:	Absorbed by water (high absorption coefficient in water)

Neodymium: Yattrium: Aluminom-Garnet Myers and Myers (1985) Were the First to Use Myers it in Dentistry

Abbreviation	:	Nd: YAG
Wavelength	:	1.064 µm
Wave form	:	Pulsed
Delivery tip	:	Flexible fiber optic system of varying diameters; surface contact required for most procedures
Reported Use	:	Soft tissue incision and ablation; subgingival curettage and bacterial elimination
Tissue reaction	:	Have low absorption coefficient in water than CO_2 lasers but preferentially absorbed in pigmented tissues

Erbium: Yattrium:- Aluminum-Garnet

Abbreviation	:	Er: YAG
Wavelength	:	2.94 µm
Wave form	:	Free running-pulsed
Delivery tip	:	Flexible fiberoptic system or hollow wave guide; surgface contact required for must procedures
Reported use in periodontics	:	Soft tissue incision and ablation; subgingival (curettage and bacterial elimination, scaling of root surfaces, osteoplasty and ostectomy
Tissue reaction	:	Highly absorbed in both water and hydroxyapatite

Diodes

- Indium -gallium-arsenide-phosphide (InGa AsP)
- Gallium-alluninum-arsenide (GaAIAs)
- Gallium-arsenide (GaAs)
- Commonly Called diode-lasers

Wavelength : 635 to 950 nm
Wave form : Gated or continuous
Delivery tip : Flexible fiberoptic system; surface contact required for mest procedures
Reported use : Soft tissue incision and ablation; subgingival curettage and bacterial elimination
Tissue reaction : Low absorption coefficient in water but are preferentially absorbed in pigmented tissues

Erbium, Chromium: Yattrium: Selenium-Gallium-Garnet

Abbreviation : Er, Cr,: YSGG
Wavelength : 2.78 μm
Wave form : Free running-pulsed
Delivery tip : Flexible fiber optic system sapphire crystals of varying diameters; surface contact required for most procedures
Reported use : Incision sablatium, subgingival curettage, asteuplasty, astectomy
Tissue reaction : Absorbed in both water and hydroxyapatite

Holmium: Yattrium-Aluminum-Garnet

Abbreviation : Ho: YAG
Wavelength : 2.1 μm
Wave form : Pulsed
Delivery tip : Flexible fiber optic system; surface contact required
Reported use : Soft tissue ablation and incision; subgingival curettage and bacterial elimination

Argon

Abbreviation : Ar
Wavelength : 488-514 nm
Wave form : Gated or continuous
Delivery tip : Flexible fiber optic system
Use : Soft tissue incision and ablation
Tissue reaction : Preferentially absorbed by pigmented tissues

CLINICAL ASPECTS

Oral soft tissues: Laser is a viable alternative to the scalpel for various soft tissue procedures such as frenectomy, gingivectomy and gingivoplasty, de-epithelization of reflected periodontal flaps, removal of granulation tissue, second stage exposure of dental implants, lesion ablation, incisional and excisional biopsies of both benign and malignant lesions, irradiation of aphthous ulcers, coagulation of free gingival graft donor sites and gingival depigmentation (Cobb, 2006).

Advantages of lasers: (Bader, 2000; Powell, 1992):

- Dry surgical field and better visualization
- Tissue surface sterilization and reduction in bacteremia
- Decreased swelling, edema and scarring
- Decreased pain
- Faster healing response
- Increased patient acceptance

Pain reduction may be due to the protein coagulum that is formed on the wound surface, thereby acting as a biologic dressing and sealing the ends of the sensory nerves (Schuller, 1990).

The rapid wound healing after using lasers may be related to the photobiomodulation. Photobiomodulation (PBM) or the Low-Level Laser Therapy (LLLT) is the application of electromagnetic energy in the red and near infrared region to damaged or diseased tissue.

LLLT may occur simultaneously with the high level laser therapy at the periphery of the target tissue, therefore, explain some of the advantages of lasers at high level laser therapy. PBM modality works at cellular levels by: promoting faster healing and return to norm, with a reduction in toxins via: accelerating lymphatic flow and increasing blood; thereby helping to: reduce pain, enhance repair and induce regeneration. In addition, LLLT contributed to a larger expression of collagen and elastic fibers during the early phases of the wound healing process (Pugliese *et al.*, 2003).

Damante *et al.* (2004) and Masse *et al.* (1993) reported no evidence of accelerated healing following flap surgery, using 670 and 810 nm diode lasers, respectively. Lastly almost as a casual observation, several studies have reported that laser induced wounds show a decreased tendency toward scar contraction compared to traditional scalpel surgeries (Hendrick *et al.*, 1995; Zaffe *et al.*, 2004).

Oral hard tissues

- USES
- Ostectomy
- Osteoplasty
- Implant site prepration

Given that laser/biologic tissue interaction are photo thermal events that, in turn, are wavelength dependent, with the possible exemption of two wavelengths (Er: YAG and Er, Cr: YSGG) the effect of most dental lasers on bone is generally detrimental (Cobb, 2006).

Severe collateral damage has been identified as a major factor in delayed healing of laser induced bone incisions. Carbonization and major thermal damage have been reported on the target and adjacent tissues (Cobb, 2006).

When considering laser mediated osteotomy or ostectomy, the Er, Cr: YSGG appears to be a popular laser with clinicians. Kimura *et al.* (2001) evaluated the morphological and temperature changes in canine mandibular bone, *in vitro*, following irradiation with the Er, Cr: YSGG laser and found no changes in calcium/phosphate ratio (EDX-analysis) and no evidence of charring or metting. Thus the erbium laser group has emerged as a promising laser for periodontal indications; however, further research is needed before they can be recommended for these purposes (Abu-Serriah *et al.*, 2004; Stubinger *et al.*, 2007a, b).

Use of laser for clinical crown lengthening: Er. Cr: YSGG laser and to a lesser extent the Er:YAG laser, has been promoted for clinical crown lengthening without gingival flap reflection for both esthetic and prosthetic reasons.

Currently, there are, no controlled longitudinal or cohort studies supporting use of lasers for clinical crown lengthening using closed flap technique.

Effect of lasers on bacteria and calculus: There is limited evidence suggesting that lasers effect greater reduction in Subgingival bacteria than that achieved by traditional therapy.

When it comes to calculus removal using lasers (Aoki *et al.*, 2004) reported an equivalent effect using ultrasonic instrumentation or Er: YAG laser for the invitro removal of calculus from extracted teeth.

The alexandrite laser is a solid-state laser, which could remove dental calculus selectively (Rechmann and Henning, 1996). Mechanism of selective ablation has not been clarified yet. The development of this laser for clinical use is widely expected due to its excellent ability for selective calculus removal from the tooth structure.

Treatment of chronic periodontitis: Laser mediated periodontal therapy is predicted on the concept of subgingival curettage and/or reattachment and regeneration of the attachment apparatus. Such laser therap is commonly reffered to as non-surgical. Studies regarding the use of lasers in periodontial disease management have been done using different types of lasers (ag. CO_2, Nd: YAG, diodes, Er: YAG) results of these studies are conflicting as some studies suggest that lasers can be used as a monotherapy in periodontal therapy (Romanos, 1994; Gold and Vilardi, 1994) while others are contradictory (Yukna *et al.*, 2007; Radvar *et al.*, 1996; Harris *et al.*, 2004). It can be simply put in this way that there is insufficient evidence to suggest that any specific wavelength of laser is superior to the traditional modalities of therapy.

Laser safety: Following safety measures should be taken:

- Should be operated in an environment with limited access and minimal reflective surfaces
- Wearing of wavelength specific protective eye wear (Cy, Argon-orange; CO_2-clear/White coloured) by the operation patient
- Another important part of laser safety is properly trained staff regarding the above protocols

Other applications (Walsh, 2003; Coluzzi and Goldstein, 2004):

- Laser fluorescence detection of dental caries
- Laser fluorescence detection of subgingival calculus
- Laser Doppler flowmetry to assess dental pulp blood flow
- Photoactivated dye disinfections

Lower power laser is used for photochemical activation of oxygen releasing dyes (PAD). Singlet oxygen released from the dyes causes membrane and DNA damage to microorganisms. e.g., Root-canal disinfection; disinfection of periodontal pockets.

- Photodynamic therapy-a more powerful photochemical reaction initiated by laser can be used to generate reactive oxygen species. This has been employed in the treatment of malignancies of oral mucosa
- Laser enhanced tooth whitening
  - Photochemical bleaching
  - Photothermal bleaching
- Dental laboratory uses
  - Scanning of crown preparations for CAD-CAM
  - Sintering of ceramics
  - Cutting of ceramics

CONCLUSION

In summary, the application of lasers has been recognized as an adjunctive or alternative approach in periodontal and peri-implant therapy. Soft tissue surgery is one of the major indications of lasers. CO_2, Nd:YAG, diode, Er:YAG and Er, Cr:YAG lasers are generally accepted as useful tools for these procedures. Laser treatments have been shown to be superior to conventional mechanical approaches with regards to easy ablation, decontamination and hemostasis, as well as less surgical and postoperative pain in soft tissue management. Laser or laser-assisted pocket therapy is expected to become a new technical modality in periodontics. The Er:YAG laser shows the most promise for root surface debridement, such as calculus removal and decontamination. Concerning the use of lasers for bone surgery, CO_2 and Nd:YAG lasers are considered unsuitable because of carbonization and degeneration of hard tissue. Among lasers currently available, the Er:YAG laser seems to provide the most suitable characteristics for various types of periodontal treatment.

Finally, in order to have a successful periodontal treatment in long term, patients need to be motivated. It is not so much the technology but the motivation and psychology that matter when it comes to practice of oral hygiene before, during and after the periodontal treatment to maintain a good and stable periodontal condition.

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