Romanian Biotechnological Letters *Vol. , No. x,*

ORIGINAL PAPER

Laser's applications in minimally invasive dental procedures – new trends in modern dentistry

Received for publication, July 2nd, 2017
Accepted, October 20th, 2017

M. MELEȘCANU IMRE[1], A. CELIBIDACHE[4], A.M.C. ȚÂNCU[1], M. PANTEA[2], I. SUCIU[3], P. PERLEA[3]
[1] *Department of Prosthodontics – Complete dentures, Faculty of Dentistry," Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania*
[2] *Department of Prosthodontics – Fixed prosthodontics and occlusology, Faculty of Dentistry," Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania*
[3] *Department of Endodontics – Faculty of Dentistry," Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania*
[4] *Private practice*
Corresponding author: A.M.C. Țâncu: amctancu@yahoo.com / +40722664355

Abstract

This paper wants to highlight the multiple use and advantages of dental lasers in modern dentistry.

These lasers, especially developed for this field, are surgical and therapeutic devices in the vanguard of technology, used by a bigger and bigger number of doctors in daily practice. The dental lasers use 4 classes of wavelengths which are absorbed in soft or hard tissue and give them a precise tissue specificity. Their clinical applicability is very wide and complex and they offer a very good comfort for the patient. Three clinical cases will describe the multiple and various applications of the dental lasers, depending on the used power, exposure time and absorption of the wavelengths in soft or hard tissues, highlighting the benefits for every case.

Key words: lasers, minimally invasive procedures, advanced dental treatment

1. Introduction

Modern dentistry is minimally invasive. This aim can be reached by the use of laser in dentistry. The popularity of dental lasers has grown a lot in the last few years, 20 % of the world's dental practitioners use them in the daily practice. The current paper wants to highlight the aspects that contribute at the rapid development of this field.

The advantages of these instruments are multiple and known by a bigger and bigger number of specialists, due also the growth number of dental courses in the field of dental lasers, during the undergraduate and postgraduate programs in many dental faculties in the world.

Modern dental lasers, some developed especially and exclusively for this field, produced by well - known producers in the world, are therapeutic and surgical devices in the vanguard of technology, used in: periodontology, implantology, prosthodontics, restaurative odontology, endodontics, oromaxilar surgery, pedodontics, orthodontics.

2. Materials and method.

In dentistry laser has today multiple and various applications which depend on the used power and exposure time of the dental tissues, but also on the absorption of the wavelengths in soft or hard tissues.

Laser light has 4 types of interaction with the targeted tissues which depends on the optical properties of that tissue – absorption, transmission of laser energy, reflection, scattering of the laser energy. Nowadays we have lasers divided in 4 big classes of wavelengths that are used in dentistry, under different brands and names. These wavelengths are in:

- visible spectrum between 400 – 700 (diode, Nd: YAG)
- infrared until 2000 nm (Nd: YAG 1064 nm)
- mid-infrared from 2000-3000 nm (Er: YAG, Er, Cr: YSGG)
- far infrared such as CO2 – 9600 nm, 10.600 nm

The three most popular soft tissue wavelengths used in dentistry are diode, Nd: YAG and carbon dioxide, with Er, Cr: YSGG and Er: YAG quickly closing ground because of their versatility and unique ability to cut soft tissues with minimal thermal impact.

Lasers, related to the work wavelengths, have a precise tissue specificity, thus some wave lengths are absorbed more in:

- hydroxyapatite - that we find in hard tissues (CO2 laser)
- water that we find in soft and hard tissues (Er, Cr, YSGG, Er: YAG)
- melanin, a pigment that we find in decays and infected tissues (940 nm, 980nm diodes and Nd: YAG 1064 nm)
- Hb (Hemoglobin) that we find in vessels, soft tissues, granulation tissues (diodes of 940 nm, 980 nm and 655 -980 nm

Table 1. Wavelength of laser light used and target tissue

Type of lasers	**Wavelength(nm) Pulse mode**	**Cromophores used**	**Target tissue**
Diode	850-1064	Pigments	Gingiva, mucosa
		Hemoglobin	
		Melanin	
Nd: YAG	1064	Pigments	Gingiva, mucosa
		Hemoglobin	
		Melanin	
Er: YAG	2940	Water	Gingiva, mucosa
		Hydroxiapatyte	Enamel, dentin, bone
Er, Cr: YSGG	2860	Water	Gingiva, mucosa
		Hydroxiapatyte	Enamel, dentin, bone
CO2	10640	Water	Gingiva, mucosa
			Enamel, dentin, bone

Such as the wavelengths of the visible spectrum are absorbed in different colors, the wavelengths of the dental laser are absorbed in water, hydroxyapatite and pigmented tissues (soft tissues that contain different pigments, such as hemoglobin and oxyhemoglobin).

Thus, we remind some treatments and medical procedures that the can be done with the dental laser: the decays treatment (from diagnosis to the cavity preparation and fillings), the

treatment of the dentinal hyperesthesia (by the sealing of the dentinal tubes, dental whitenings and on soft tissues: gingivectomy and gingivoplasty, frenectomy and frenoplasty, the removing of the ulcerous thrushes, the removing of benign tumors and the dental implants uncover [1]

Clinical applicability of the various dental lasers

The CO2 laser is water or aircooled gas discharge, containing a gaseous mixture with CO2 molecules that helps in producing a beam of infrared light. It works at a *wave length of 10600 nm.*
It is well absorbed by water and delivered through a hollow tube-like waveguide in continuous or pulsed mode.
The CO2 laser is used especially in the dental surgery, being an ablative laser that acts especially in hard tissues. Due to the big capacity of absorption in hydroxyapatite it is a very powerful laser that needs special experience in its handling because the danger of overheating the interacting tissue exists. [2]
The Chromium: Yttrium – Scandium – Gallium – Garmet, Cr: YSGG is a laser which has an active medium of solid crystal of yttrium scandium gallium garnet doped with erbium and chromium. [3,4]
The *wawelength of 2780 nm* is absorbed especially in water, that we can find in all the tissues in the oral cavity, in a smaller or bigger percentage.
This laser is an ablative one, having the capacity of cutting the hard tissues: enamel, dentine, bone and soft tissues – gingivoplasty and gingyvectomy, the removing of granulation tissue and also tumours. The ablation is done using the water, throughout a thermo- dynamic – ablative mechanism (T.M.A.). The water molecules absorb the radiant energy, get hot and distend instantaneous than explode. In this water vaporization process, a pressure trains the organic or inorganic substance that we want to remove, achieving the ablation.
Also, throughout this mechanism, we can remove the necrotic tissue, filled with bacteria, existing in the decay process and also for the cleaning and sterilization of the infected radicular channels in gangrenes, granuloma, radicular cysts, till sane tissue.
This heating and vaporization phenomena takes place only at the interaction surface between water and tissue without warming up the adjacent tissues (soft tissues in the neighbourhood, pulpal elements, in maximum safety conditions.
Neodymium – doped: Yttrium- Aluminium Garnet (Nd: YAG) is a solid active medium which is a garnet crystal combined with rare earth elements yttrium and aluminium doped with neodymium ions. The adjacent tissue sterilization can be done using *another wavelength, of 940 nm,* which is not being absorbed by the hydroxyapatite, case in which the energy will be sent to the adjacent soft tissues, but by melanin and Hb. In this way, we achieve the sterilization of the adjacent soft tissues, in the case of marginal periodontitis, apical periodontitis, gangrene, granuloma and radicular cysts, eliminating the flap surgery.
The sterilization process takes place by –OH group release, that comes out from the water molecules dissociation. This – OH groups have bactericide properties. The laser energy being absorbed by the water from the organic bacterial content from the dentinal channels throughout T.M.A. (thermo – mechanical – ablative) mechanism, the bacteria removal takes place at this level too. In the classical treatments, the sterilization of the radicular channels

was possible only for 60%. Now is possible for 99%.
The Low Level Laser Therapy – LLLT uses a *wavelenght of 660 nm*.
Dentinal hypersensitivity is the most frequent and common causes of dental pain. LLLT inhibit the release of mediators from injured tissues. They decrease concentration of chemical agents such as histamine, acetylcholine, serotonin, H+, K+, all of which are pain mediators. [5]

Table 2. Laser dental application

Application	Possible laser types
Basic research	All types
Laser tissue interaction	
Oral medicine	He, Ne, diodes
Laser Doppler flowmetry	He, Ne, diodes
Laser induced fluorescence (diagnosis of decays)	Diode
Photodynamic therapy (for treatment of oral cancer)	
To release fibrotic bands in OSMF	ErCr: YSGG
Oral soft tissue lesions frictional kearatosis, leukoplakia, verucos carcinoma	Diode
Oral and maxillofacial surgery	
To achieve haemostasis	CO2
Tuberosity reduction, alveoloplasty, bone and flap removal	Erbium
Conservative dentistry	CO2, Nd: YAG, Er: YAG
DH	
Cavity preparation	Diode
Composite resin light curing	CO2, Nd: YAG, Er: YAG
Tooth surface conditioning, removal of defective composite restoration	Argon, Er: YAG
Endodontics	Nd: YAG, CO2
Root canal treatment, apicectomy	
Periodontics	
Laser assisted curettage	Nd: YAG, diode
Gingivectomy and gingivoplasty	CO2
Analgesic effect and bio stimulation	
Stimulation of wound healing	He Ne, diodes, Nd: YAG

3. Results and discussions

Aspects concerning clinical applicability of lasers in dentistry are illustrated through three clinical cases; the applied laser treatments involve hard and soft oral tissues as well. The benefits of laser therapy, for different fields in dentistry, are highlighted for each clinical case.
Clinical case 1 – Prosthetic rehabilitation with ceramic veneers, including gingivoplasty with

laser therapy / *2780 nm Er, Cr: YSGG*

The patient, a 44 years old female, was a non smoker, with no medication for chronic diseases, no history of systemic diseases or allergies, no general-health risk factors. The patient reported a history of traumatic injury at the upper front teeth (1.1. and 2.1.) 10 years ago; these teeth were subsequently covered with ceramic dental veneers.

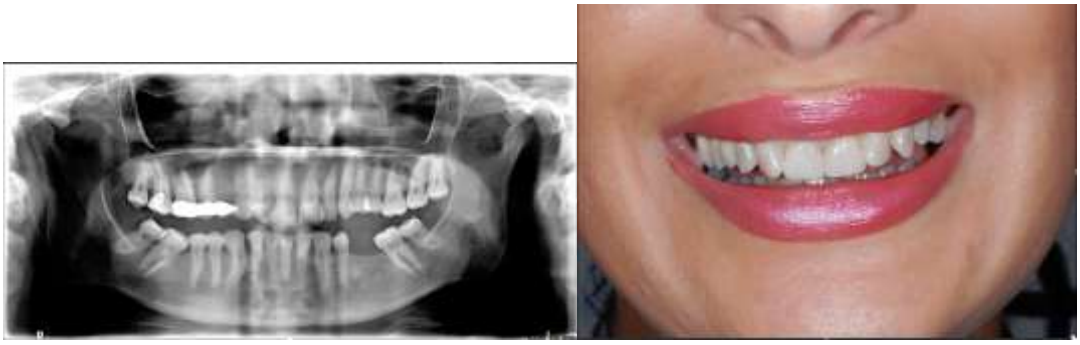

Fig. 1 Case 1 – Initial panoramic X-ray and clinical aspect

Clinical and radiological findings showed (Fig.1): dental-alveolar disharmony, especially in upper dental arch, with abrasion areas and decreased vertical occlusion dimension; improper ceramic veneers on teeth 1.1; 2.1.; teeth 2.2. and 2.3. - rotated with mesial-buccal aspect toward buccal; malocclusion; good oral hygiene.

Our therapeutic goals consisted of an aesthetic rehabilitation of the maxillary anterior zone - ceramic veneers from teeth 1.5. to 2.4. The preparation involved the *2780 nm Water Lase MD.* The settled clinical protocol implied: choosing the tips - *MC3 and MZ8*; fixing the right laser parameters; dental-surface polishing using *MD-2780 nm* laser for teeth 1.2., 2.2., 2.3. and slightly for tooth 2.4.; additional gingivoplasty at tooth 1.1.; finishing and smoothing polished surfaces of prepared teeth and gingivoplasty; impression and temporary restorations. Laser parameters were establish as shown in Table 3.

Table 3. Laser parameters corresponding to clinical case 1

Teeth polishing	Teeth finish	Gingivoplasty	Gingival shape
MC3	MZ8	MZ8	MZ8
H MODE	H MODE S	MODE S	MOD E
PPS: 25-30 Hz	PPS: 50 Hz	PPS: 25 Hz	PPS:50Hz
P: 4,75 W	P: 5,25 W	P: 2 W	P: 2 W
WATER-89%	WATER-90%	WATER-50 %	WATER-50%
AIR-78%	AIR-80%	AIR-30%	AIR-30%

Fig. 2 Clinical case 1 - Preparation of frontal upper teeth

Clinical aspect after the preparation of the teeth and gingivectomy (procedures that implied 45 min. working time) and before the final impression is shown in Fig. 2. The temporary restorations were obtained in the same appointment (Fig. 3) and the final results of the treatment is shown in Fig. 4.

Fig. 3 Clinical case 1 – the temporary restorations in place

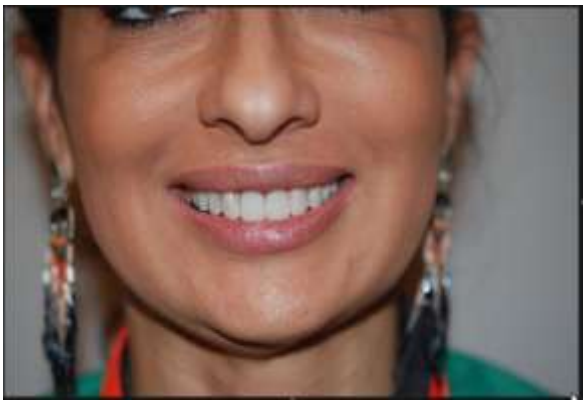

Fig. 4 Clinical case 1 - Before and after the treatment

The advantages of using a *2780 nm laser* for this clinical case are: no anaesthesia required; minimally invasive procedure; protective with the dental pulp, preserving teeth vitality; teeth surface remains sterile, with no smear layer; minimal bleeding and quick heeling after gingivectomy. Furthermore, advantages for the final impression and for obtaining the temporary restorations are important: increased comfort for the patient; decreased working-time and costs efficiency for medical staff.

Clinical case 2 - periodontal abcess treatment performed with *DIODE and 2780 nm Er,Cr:YSGG*

For this patient – a 56 years old female – the general anamnesis showed: no history of any systemic disease or allergy; risk factors - 30 years of smoking, stressful work environment; no medications. The patient reported dental pain and swelling in area of the teeth 2.6. and 2.7.; she also reported teeth cold sensitivity.

Clinical and radiological findings in the area of teeth 2.6. and 2.7**.** were as follows: gingival abcess / edema around teeth 2.6., 2.7., pain and bleeding; vertical axis percussion - negative response, lateral percussion – positive response; positive vitality test; no teeth mobility; tooth 2.7. had no antagonist and presented a dental crown without flat contours, with no proper convexity for gingival protection. The patient had incorrect frontal and bi-lateral guidance, presenting premature contacts and interferences. The Panoramic X-ray revealed (Fig. 5): advanced bone resorption; multiple abfraction lesions; enlarged inter-dental space between teeth 2.6. and 2.7. allowing the gingival abscess formation.

Fig. 5 Clinical case 2 –initial panoramic X-ray

Fig. 6 Clinical case 2 - Periodontal examination

The periodontal examination confirmed: infected periodontal pocket between teeth 2.6-2.7. and vestibular abscess; pockets dimension for tooth 2.6: Vestibular - 4,5mm, Distal -7mm, Oral - 4,5mm; pockets dimension for tooth 2.7: Vestibular - 5 mm, Mesial - 7mm, Oral - 4,5 mm (Fig. 6).
The treatment plan involved multiple sessions:
- First session: emergency procedure for teeth 2.6., 2.7. - scaling and brushing; mild disinfection with *940nm diode Epic Laser;* periodontal curettage using *2780nm MD-L.L.L.T bio-stimulation*
- Second session: artificial crown removal for tooth 2.7.; temporary crown on tooth 2.7. with a strong proximal contact and with correct buccal convexity
- Third session: general periodontal laser assisted treatment in 4 sessions using laser (*Diode and Er, Cr:YSGG)* (Fig. 7)
- Fourth session: protocols to obtain a new crown for tooth 2.7., that had to be connected with a prosthetic restoration on tooth 2.6., to avoid vertical migration of tooth 2.7
Laser parameters for the first session were: for *940nm* - 1 W; CW; 300 µm non-activated; for *Water Lase MD 9 mm* – RTF; H MODE; P - 1,5 W; PPS-30 Hz; Water-70%; Air-60%.

Fig.7 Clinical case 2 - immediately after laser therapy

Clinical case 3 – Upper labial frenotomy with *Er,Cr:YSGG 2780 nm* laser
A 28 years old female patient, nonsmoker, with no chronic medication, no history of systemic diseases or allergies and no risk factors, presented no cavities, good oral hygiene and a correct vertical occlusal dimension. She was unsatisfied about her gummy smile, with severe aesthetic implications (Fig. 8). The intra-oral examination revealed a large and low attached upper lip insertions (Fig. 9).

Fig. 8 Clinical case 3 – gummy smile

Fig. 9 – Clinical case 3 – upper lip insertion

In order to change the upper lip insertion position, the following laser parameters were established for *Water Lase MD 9 mm*: MZ8; S MODE; P-2W; PPS-50 Hz; Water-50%; Air-30%. The results of the laser treatment are shown in Fig. 10 and Fig. 11

Fig. 10 Clinical case 3 - 10 minutes after the laser intervention

Fig. 11 Clinical case 3 - before and after treatment

Laser therapy has a lot of useful applications in the field of dentistry, as also shown in the presented clinical cases. In conservative dentistry, the laser therapy can be used for: decays, the sterilization of the infected root canals, granuloma and radicular cysts treatment without surgical procedures, micro retentions, teeth desensitization etc. Oral surgery benefit of laser's advantages in different procedures: sinus lift, extractions without anaesthesia in allergic patients or kids; abscess incision and fistula sterilization; frenectomy; the removing of intraoral tumors. In periodontology lasers could be used for the sterilization of periodontal pockets. Laser therapy is also used in prosthodontics (elongation of the dental crown – gingivoplasty, with no anaesthesia; luting of the non- prep veneers), in orthodontics (stripping; gingivectomies in case of periodontal inflammations that sometimes accompany these treatments), in implantology (woundhealing and biostimulation) and in oral pathology (for herpetic oral lesions).

Corresponding to the presented clinical cases, relevant advantages of laser therapy in dentistry are highlighted, as follows.
For most of the laser performed interventions, no anaesthesia is required, due to the laser physical properties. This aspect has very important outcomes in paediatric dentistry but also in grown – up treatments, for patients with high risks of allergy or intolerance to anaesthetics.
Laser therapy implies minimally invasive oral procedures, which is one of the first requirements in modern dentistry, assuming a minimum loss of teeth structure [6,7]. It is also protective with the dental pulp, preserving the teeth vitality.
Tooth surface remains sterile after laser treatments, with no smear layer detected, so there is no risk of contamination, which is essential for successful endodontic and restorative dentistry.
The minimal bleeding corresponding to laser oral therapies is a very important effect especially for extended surgical procedures followed by prosthetic interventions, such as impression taking, for natural teeth or in implant supported restorations [8].
The quick healing after surgical and periodontal procedures involving lasers offers different advantages that consist of: reduced treatment duration in complex clinical cases or in full oral rehabilitations; increased patients' acceptance of treatment plan; increased comfort for the patient - less pain, no post-op oedema.
Laser oral therapies provide stimulation of regenerative and healing processes by Calcitonin - gene - immune re-active (CRRP-IR) and stimulation of alkaline phosphatase (TMAP), which leads to rapid regeneration after periodontal and conservative procedures.
For the medical staff, these procedures show great advantages regarding time and costs efficiency, due to less and shorter clinical sessions.
There are also some indirect limitations of laser applications in dentistry, such as the requirements for additional training and education for medical practitioners; also, in order to purchase and implement this technology, an initial high cost is required [9].
The correct use of parameters, protocols and techniques belonging to modern laser technologies assure a predictable success, with a favourable biological effect [10]
Learning the variations of the parameters and operative modalities, it is possible to control and condition the quantity and quality of irradiation on the tissue, foreseeing the biological effects and reducing the collateral risks in the use of laser technology. [10]

4. Conclusions

New laser generations offer a precise control in tissue cutting, for different procedures and corresponding to diverse tissue biotypes, cutting cleanly the soft tissues, with good haemostasis and high comfort for the patient.
One of the big advantages of dental laser medicine is the possibility to do more, with less anaesthetic and smaller injury of the dental tissue.
For sure, these advantages convert laser therapy into a necessary element for the future dental practice, likewise in the other medical fields.
It is essential for the dentists to be informed and trained on the lasers' technical features and, also, on the multiple applications of lasers in dentistry.

References

1. C.J. WALINSKI. An analysis of factors driving soft tissue laser adoption. *10-11, JLAD,* (Fall 2014).
2. M. A. POGREL, D.F. MUFF, G.W. MARSHALL. Structural changes in dental enamel induced by high energy continuous wave carbon dioxide laser. *Lasers in Surgery and Medicine*, **13**:89-96 pp, (1993).
3. M. HOSSAIN, Y. NAKAMURA, Y. YAMADA, Y. KIMURA, N. MATSUMOTO, K. MATSUMOTO. Effects of Er, Cr: YSGG laser irradiation in human enamel and dentin: Ablation and morphological studies. *Journal of Clinical Laser in Medicine and Surgery*, **17**:155-9 (1999).
4. M. FRENTZEN, H.J. HOORT. The effect of Er: YAG irradiation on enamel and dentin. *Journal of Restorative Dentistry*, 71:571 (1992).
5. H.R. KHALIGHI, F. ANBARI, J. BEYGOM TAHERI, S. BAKHTIARI, Z. NAMAZI, F. POURALIBABA. Effect of low-power laser on treatment of orofacial pain. *Journal of Dental Research, Dental Clinics, Dent Prospects*, 4:75-8 (2010).
6. A.A. EL-HOUSSEINY, H. JAMJOUM. Evaluation of visual, explorer and a laser device for detection of early occlusal caries. *Journal of Clinic Paediatric Dentistry,* 26:41-8 (2001).
7. L.E. TAM, D. MCCOMB. Diagnosis of occlusal caries: Part II. Recent diagnostic technologies. *Journal of Canadian Dental Association,* 67:459-63 (2001).
8. R.M. PICK, B.C. PECARO. Use of the CO2 laser in soft tissue dental surgery. *Lasers in Surgery and Medicine*, 7:207-13 (1987).
9. C.M. DAVID, P. GUPTA. Lasers in Dentistry: A Review. *International Journal of Advanced Health Science*, 8:7-13 (2015).
10. G. OLIVI, R. DE MOOR, E. DIVITO. Lasers in Endodontics. *Springer International Publishing*, Chapter 4, pag.80-81 (2016).