Romanian Biotechnological Letters *Vol. 23, No. 6, 2018*

ORIGINAL PAPER

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

DOI: 10.26327/RBL2017.77

Received for publication, July, 2, 2017
Accepted, October, 20, 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, Romania
***Corresponding author:** A.M.C. Țâncu: amctancu@yahoo.com /* +40722664355

Abstract

The present paper highlights the multiple uses and advantages of dental lasers in modern dentistry. Especially developed for this medical field, dental lasers are surgical and therapeutic high technology devices, which are increasingly used in the daily dentists' practice. The dental lasers use four classes of wavelengths which are absorbed in soft or hard tissues, thus providing precise tissue specificity. They are used at a large scale thanks to their minimally invasive particularity. In this context, the present paper presents three clinical cases in which dental lasers are applied using different laser light power, exposure time and absorption of the wavelengths in soft or hard tissues thus highlighting the benefits for every presented case.

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

1. Introduction

Modern dentistry is minimally invasive; the use of dental lasers successfully contributes to reaching this aim. The popularity of dental lasers has grown a lot in the last few years and the advantages of laser therapy became well known in the area of dentistry, as scientific literature reports its benefits and, also, as courses in the field of dental lasers for undergraduate and postgraduate programs are organized. Modern dental lasers, developed exclusively for this field, are therapeutic and surgical devices that can be used in periodontology, implantology, prosthodontics, restorative odontology, endodontics, oromaxillary surgery, pedodontics, orthodontics. The current paper presents clinical aspects related to the use of lasers in modern dentistry, highlighting the advantages of these procedures.

2. Materials and method

Lasers has multiple and various applications in nowadays dentistry; differences between procedures depend on the laser light power and the exposure time of the oral tissues, but also on the absorption of the wavelengths in soft or hard tissues. Laser light has four types of interaction with the targeted tissues which depends on the optical properties of that specific tissue – absorption, transmission of laser energy, reflection, scattering of the laser energy. Lasers are divided in four big classes of wavelengths that are used in dentistry, under different

brands and names. These wavelengths are in: visible spectrum between 400 – 700 nm (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 CO_2 – 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.

Related to the work wavelengths, lasers have a precise tissue specificity, thus some wavelengths are absorbed more in different tissues, as follows:

- hydroxyapatite – found in hard tissues (CO_2 laser)
- water – found in soft and hard tissues (Er, Cr, YSGG, Er: YAG)
- melanin, a pigment found in decays and infected tissues (940 nm, 980nm diodes and Nd: YAG 1064 nm)
- Hb (Haemoglobin) 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 and targeted tissue

Type of lasers	**Wavelength (nm) Pulse mode**	**Chromophores**	**Targeted tissue**
Diode	850-1064	Pigments	Gingiva, mucosa
		Haemoglobin	
		Melanin	
Nd: YAG	1064	Pigments	Gingiva, mucosa
		Haemoglobin	
		Melanin	
Er: YAG	2940	Water	Gingiva, mucosa
		Hydroxyapatite	Enamel, dentin, bone
Er, Cr: YSGG	2860	Water	Gingiva, mucosa
		Hydroxyapatite	Enamel, dentin, bone
CO2	10640	Water	Gingiva, mucosa
			Enamel, dentin, bone

Such as the wavelengths of the visible spectrum are absorbed in different colours, the wavelengths of the dental laser are absorbed in water, hydroxyapatite and pigmented tissues (soft tissues that contain different pigments, such as haemoglobin and oxy-haemoglobin). Thus, some specific therapies and dental procedures, compared to the traditional work-flow (GHEORGHIU [1], SUCIU [2], POLL [3]), can be done with the dental laser: decays treatment (diagnosis, cavity preparation and filling), treatment of the dentinal hyperesthesia (sealing of the dentinal tubes), dental whitening and interventions on soft tissues (gingivectomy and gingivoplasty, frenectomy and frenoplasty, removal of the ulcerous lesions, removal of benign tumours, dental implants uncovering) (WALINSKI [4]).

Clinical applicability of the various dental lasers

The CO_2 laser is water or air-cooled 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 10600nm.* It is well absorbed by water and delivered through a hollow tube-like waveguide in continuous or pulsed mode. The CO_2 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 handling experience because the danger of overheating the interacting tissue (POGREL & al. [5]).

The Chromium: Yttrium – Scandium – Gallium – Garnet, Cr: YSGG is a laser which has an active medium of solid crystal of yttrium scandium gallium garnet doped with erbium and chromium (HOSSAIN & al. [6] ; FRENTZEN & HOORT [7]). The *wavelength of 2780nm* is absorbed especially in water, that is found in all tissues from 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, removal of granulation tissue and 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, then explode. In this water vaporization process, a pressure trains the organic or inorganic substance that is to be removed, thus achieving the tissue ablation. Also, this mechanism allows to remove the necrotic tissue, filled with bacteria, existing in the decayed tooth area and for the cleaning and sterilization of the infected radicular channels in gangrenes, granuloma, radicular cysts. 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 absorbed by the hydroxyapatite, so the energy will be sent to the adjacent soft tissues and absorbed 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 endo-treatments, the sterilization of the radicular channels was possible only for 60% - now is possible for 99%. Additionally, corresponding to the quality of the apical filling, "practically half of the post-treatment stereo-microscopically investigated teeth were found to be incorrect" (PERLEA [8]).

The Low-Level Laser Therapy – LLLT – uses a *wavelength 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. (KHALIGHI & al. [9]).

Table 2. Dental lasers applications

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 keratosis, leucoplakia, verrucous 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 in the following 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. Clinical and radiological findings showed (Fig.1): multiple rotated and malpositioned teeth - 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. Clinical aspect after the preparation of the teeth and gingivectomy (procedures that implied 45 min. working time) is also shown in Fig. 1, as well as the temporary restorations (that were placed in the same appointment) and the final result of the treatment.

Figure 1. Clinical case 1 – from left to right, top row: initial panoramic X-ray and clinical aspect; bottom row: preparation of frontal upper teeth, temporary restorations in place and final result

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

Laser parameters were established 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%

Clinical case 2 – Intervention for periodontal abscess / 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 the following (Fig. 2): gingival abscess / oedema in the area of teeth 2.6., 2.7., pain and bleeding at probing; vertical axis percussion of teeth - negative response, lateral percussion - positive response; positive vitality test; no teeth mobility; loose proximal contact point between teeth 2.6. and 2.7**.;** tooth 2.7. had no antagonist and presented a dental crown with flat lateral contours, with no proper convexity for gingival protection; multiple abfraction lesions; the Panoramic X-ray revealed advanced bone resorption.

The periodontal examination confirmed: infected periodontal pocket between teeth 2.6-2.7. and vestibular abscess; periodontal pockets dimension for tooth 2.6: Vestibular - 4,5mm, Distal -7mm, Oral - 4,5mm; periodontal pockets dimension for tooth 2.7: Vestibular - 5 mm, Mesial - 7mm, Oral - 4,5 mm.

Figure 2. Clinical case 2 – from left to right: initial panoramic X-ray; periodontal examination and clinical situation immediately after laser therapy

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).*
- 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%.

Clinical case 3 – Upper labial frenotomy with *Er,Cr:YSGG 2780 nm* laser

A 28 years old female patient, non-smoker, 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; the intra-oral examination revealed a large and low attached upper lip insertions (Fig. 3).

Figure 3. Clinical case 3 – from left to right, top row: upper lip insertion and gummy smile; bottom row: 10min after laser intervention and final results

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%.

Laser therapy has a lot of useful applications in the field of dentistry. In conservative dentistry, the laser therapy can be used for: dental decays treatment, sterilization of the infected root canals, granuloma and radicular cysts treatments without implying surgical procedures, micro retentions preparation, teeth desensitization etc. Laser therapy is also applied in oral surgery: sinus lifting, extractions without anaesthesia for allergic patients or kids; abscess incision and fistula sterilization; frenotomy; removing of intraoral tumours. In periodontology lasers could be used for the sterilization of periodontal pockets. Lasers are also used in prosthodontics (elongation of the dental crown – gingivoplasty, with no anaesthesia; luting of the non- prep veneers), orthodontics (stripping; gingivectomy - in case of periodontal inflammations that sometimes accompany these treatments), implantology (wound healing and bio-stimulation) 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 is important in paediatric dentistry but also for adult patients with high risks of allergy or intolerance to anaesthetics.

Laser therapy implies minimally invasive oral procedures, which is one of the first requirement in modern dentistry, assuming a minimum loss of teeth structure (EL-HOUSSEINY & JAMJOUM [10];TAM & MCCOMB [11]). It is also protective with the dental pulp, preserving the teeth vitality. The 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 or restorative dentistry.

The minimal bleeding corresponding to laser oral therapies represents an important aspect, especially in the case of extended surgical procedures, followed by prosthetic interventions, such as impression taking - for natural teeth or implant supported restorations (PICK& PECARO [12]).

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 the 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 or conservative procedures.

For the medical staff, these procedures show great advantages regarding time and costs efficiency, due to less and shorter clinical appointments.

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 (DAVID & GUPTA [13]). The correct use of parameters, protocols and techniques belonging to modern laser technologies assure a predictable success, with a favourable biological effect (OLIVI & al. [14]). 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 (OLIVI & al. [14]).

4. Conclusions

New laser technologies provide precise control in surgical interventions on soft oral tissue of different biotypes while good haemostasis and high comfort for the patient are achieved. Another important clinical benefit of using dental lasers consists in obtaining better results using less anaesthetic and minimizing injury of the oral tissues. Given these advantages and considering the ongoing development of technology it can be concluded that the application of lasers in dental practice will necessarily extend in the future and this will inevitably lead to the dentists becoming more familiar with these procedures.

Acknowledgements
In this article, all authors have an equal contribution as the first author.

References

1. M. GHEORGHIU, V. MARASCU, D. STAICU, D. ZMARANDACHE, P. PERLEA, Comparative ultrastructural analysis of dentin surfaces mechanically prepared using carbon steel conventional burs and polymer burs. *Rom. Biotechnol. Lett*., 24(4): 12775-12784 (2017)
2. SUCIU, V. TARMURE, E. IONESCU, I. SUCIU, M. CHIRILA, I. GHEORGHE, M. POPA, A. DUMITRIU, H. URSU, Possible interaction between carious lesions, chronic marginal periodontitis, periapical pathology and salivary iodine level –preliminary results. *Rom. Biotechnol. Lett*., 23(1): 13297-13300 (2018)
3. POLL, V.R. NIMIGEAN, D. BĂDIŢĂ, R.A. BĂLĂCEANU, S.C. CISMAS, P. PERLEA, S. A. MORARU, V. NIMIGEAN, In vivo experimental model for the evaluation of dental implant integration. *Rom. Biotechnol. Lett*. 23(2): 13505-13510 (2018)
4. C.J. WALINSKI, An analysis of factors driving soft tissue laser adoption. *10-11, JLAD,* (Fall 2014).
5. 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 (1993).
6. 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).
7. M. FRENTZEN, H.J. HOORT, The effect of Er: YAG irradiation on enamel and dentin. *Journal of Restorative Dentistry*, 71: 571 (1992).
8. P. PERLEA, I. SUCIU, M. MELESCANU IMRE, M. CIOCARDEL, R.I. BARTOK, D. CRISTEA, A.A. ILIESCU, S. MILICESCU, Evaluation of apical filling using different obturation technique. *Rom. Biotechnol. Lett*., 23(2): 13375-13382 (2018)
9. 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).
10. 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).

11. L.E. TAM, D. MCCOMB, Diagnosis of occlusal caries: Part II. Recent diagnostic technologies. *Journal of Canadian Dental Association*, 67: 459-63 (2001).
12. 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).
13. C.M. DAVID, P. GUPTA, Lasers in Dentistry: A Review. *International Journal of Advanced Health Science*, 8:7-13 (2015).
14. G. OLIVI, R. DE MOOR, E. DIVITO, Lasers in Endodontics. *Springer International Publishing*, Chapter 4, pag.80-81 (2016).