The role of laser technology in implant dentistry

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- PhD in Laser Dentistry
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- Member of American Laser Dentistry
- Member of Council of Laser Research Center of Dentistry (LRCD) since 2009.

Laser

L ight

A mplification by

S timulated

E mission of

R adiation

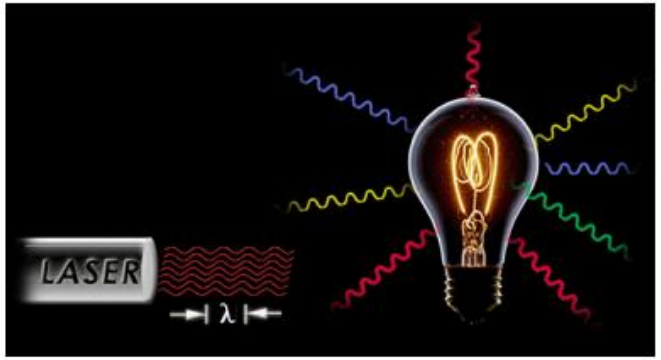
Laser

"Any device which can be made to produce or amplify electromagnetic radiation in the wavelength range from 180nm to 1mm primarily by process of controlled stimulated emission"

European Standard 1EC 601

Good dentist

- In the patient's eyes: one who does not inflict pain either during or after treatment.
- Even if we can not always fulfill these desires we should at least be able to make use of all available means of reducing the number of occasions on which our treatment causes pain.



Monochromatic

Coherence

Directional

Table 2.1 Currently available visible spectrum dental lasers

Type of laser and emission spectrum	General uses	Active medium	Wavelength	Emission mode
Semiconductor diode, visible blue	Soft tissue procedures, tooth whitening	Indium gallium nitride	445 nm	CW, GP
KTP solid-state visible light emission	Soft tissue procedures, tooth whitening	Neodymium-doped yttrium aluminum garnet (Nd:YAG) and potassium titanyl phosphate (KTP)	532 nm	CW, GP
Low-level lasers, visible red light emission semiconductor or gas lasers	Photobiomodulation therapy (PBM), photodynamic therapy (PDT), or carious lesion detection.	Variations of gallium arsenide or indium gallium arsenide phosphorus diodes Helium-neon gas	600–670 nm 632 nm	CW, GP

Table 2.2 Currently available invisible infrared dental lasers

Type of laser and emission spectrum	General uses	Active medium	Wavelength	Emission mode
Low-level lasers, (invisible) near infrared	Photobiomodulation therapy (PBM) , photodynamic therapy (PDT)	Variations of aluminum gallium arsenide diodes	800–900 nm	CW, GP
Semiconductor diode, near infrared	Soft tissue procedures	Aluminum gallium arsenide	800–830 nm	CW, GP
Semiconductor diode, near infrared	Soft tissue procedures	Aluminum/indium gallium arsenide	940 nm	CW, GP
Semiconductor diode, near infrared	Soft tissue procedures	Indium gallium arsenide	980 nm	CW, GP
Semiconductor diode, near infrared	Soft tissue procedures	Indium gallium arsenide phosphorus	1064 nm	CW, GP
Solid state, near infrared	Soft tissue procedures	Neodymium-doped yttrium aluminum garnet (Nd:YAG)	1064 nm	FRP
Solid state, near infrared	Soft tissue procedures, endoscopic procedures	Neodymium-doped yttrium aluminum perovskite (Nd:YAP)	1340 nm	FRP
Solid state, mid infrared	Soft tissue procedures, hard tissue procedures	Erbium, chromium-doped yttrium scandium gallium garnet (Er,Cr:YSGG)	2780 nm	FRP
Solid state, mid infrared	Soft tissue procedures, hard tissue procedures	Erbium-doped yttrium aluminum garnet (Er:YAG)	2940 nm	FRP
Gas, far infrared	Soft tissue procedures, hard tissue procedures	Carbon dioxide (CO_2) laser, with an active medium isotopic gas	9300 nm	FRP
Gas, far infrared	Soft tissue procedures	Carbon dioxide (CO_2) laser with an active medium of a mixture of gases	10,600 nm	CW, GP, FRP

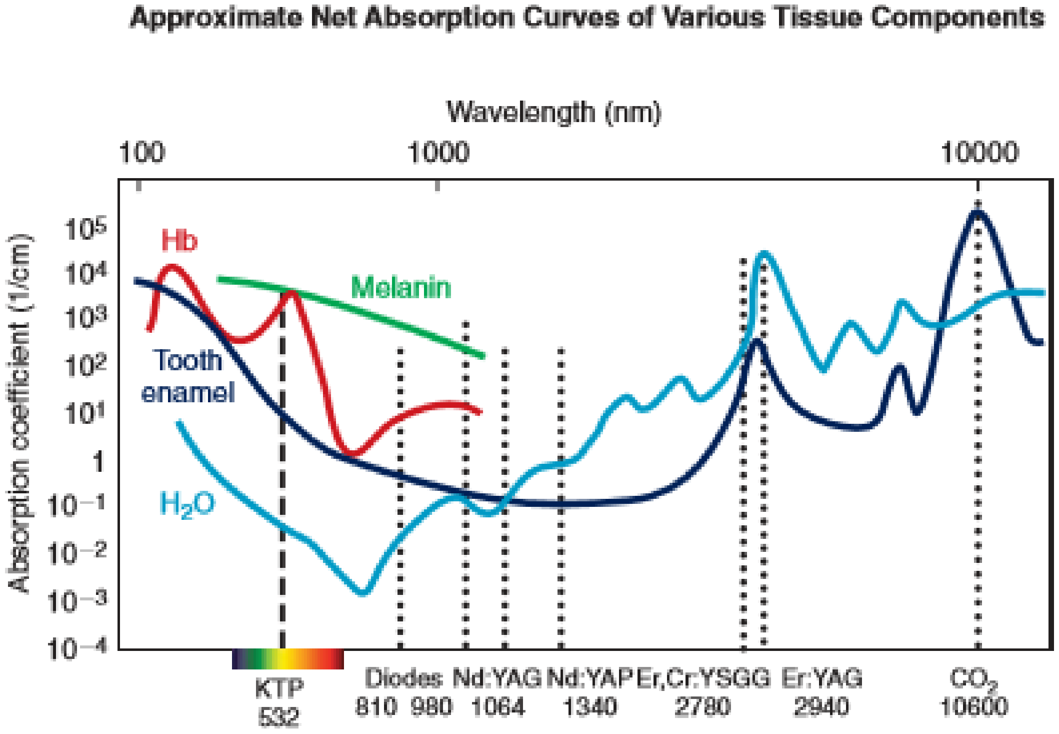
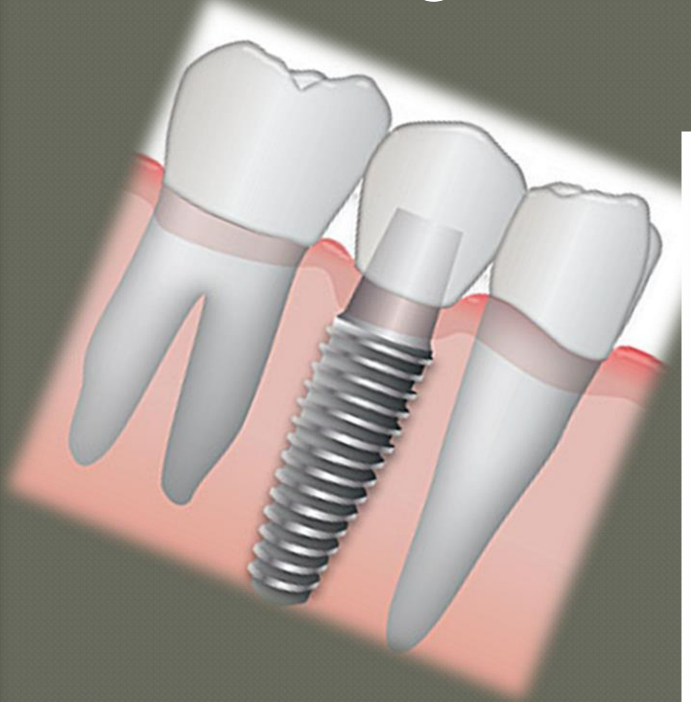
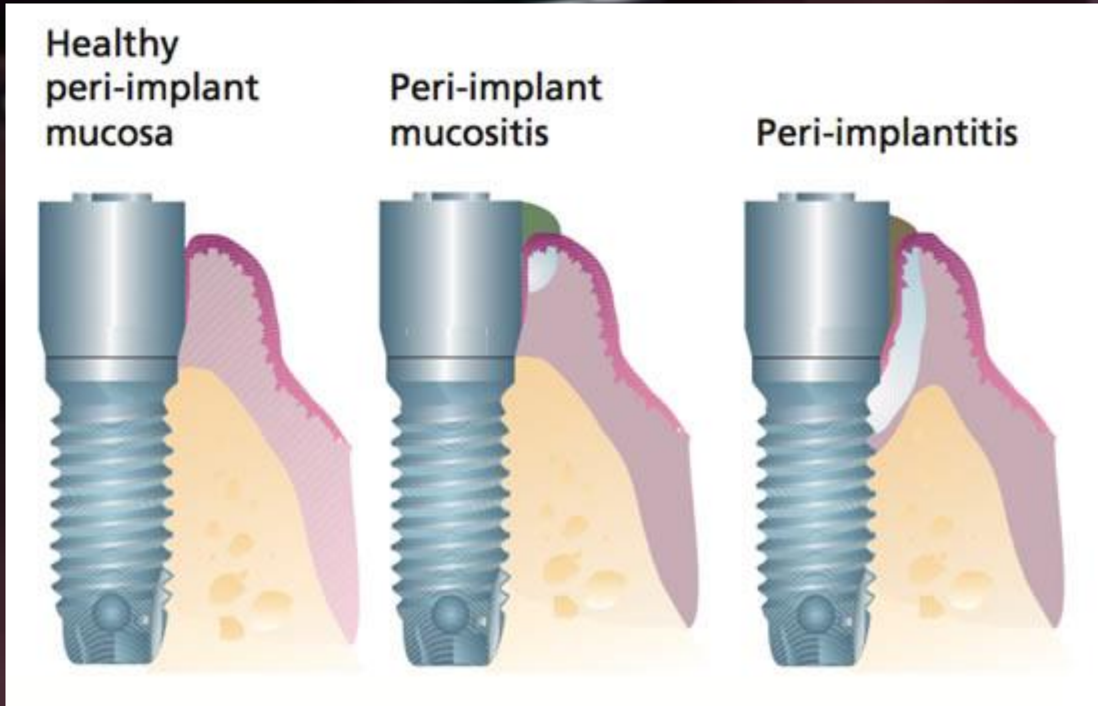


FIGURE 2-27 • Approximate absorption curves of the prime oral chromophores.

- In the recent years, dental implants have become an important part of oral rehabilitation. Due to technological and technical advancements in the past decades, dental implant success rate has reached 90% and higher



- Peri-implantitis refers to the inflammatory disease of the peri-implant tissues leading to bone loss. If not treated or controlled, progressive bone loss may eventually lead to infected implant loss
- By the growing popularity of dental implants the prevalence of peri-implantitis has increased as well



microorganisms

MDPI

Review

Effect of Different Laser Wavelengths on Periodontopathogens in Peri-Implantitis: A Review of In Vivo Studies

Katarzyna Świder [1], Marzena Dominiak [2], Kinga Grzech-Leśniak [2] and Jacek Matys [3,*]

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Received: 30 May 2019; Accepted: 26 June 2019; Published: 29 June 2019

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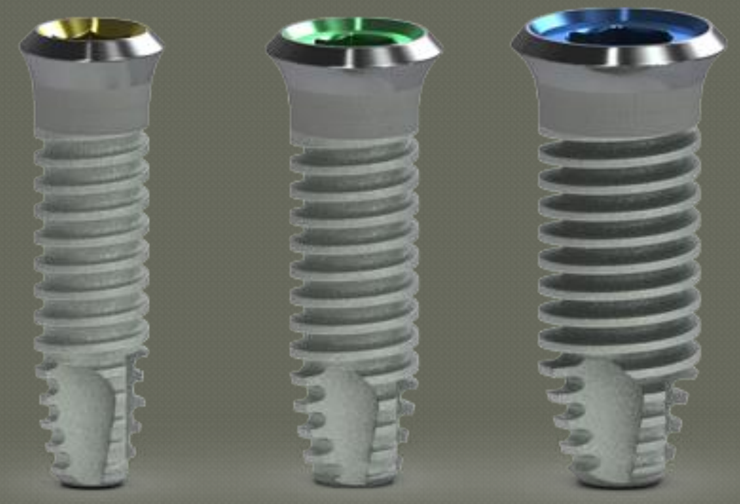
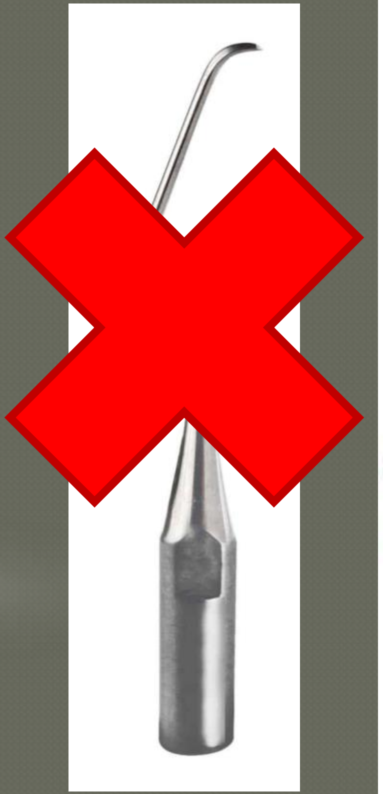
Abstract: Nowadays, many studies are examining the effectiveness of dental lasers in the treatment of peri-implantitis; however, most of them only report periodontal parameter changes. The authors of this review tried to address the question: "What is the effect of different laser wavelengths on oral bacteria that cause peri-implantitis?" An electronic search of PubMed and Cochrane Central Register of Controlled Trials was performed. The following search terms were used: (peri-implantitis OR periimplantitis) OR/AND (microbial OR microbiologic) AND (laser OR Er:YAG OR erbium OR diode OR Nd:YAG OR neodymium-doped OR Er,Cr:YSGG OR chromium-doped). Initially, 212 studies were identified. After screening the titles and abstracts and excluding studies according to predefined inclusion criteria, seven publications were included in the review. Three studies about the effect of

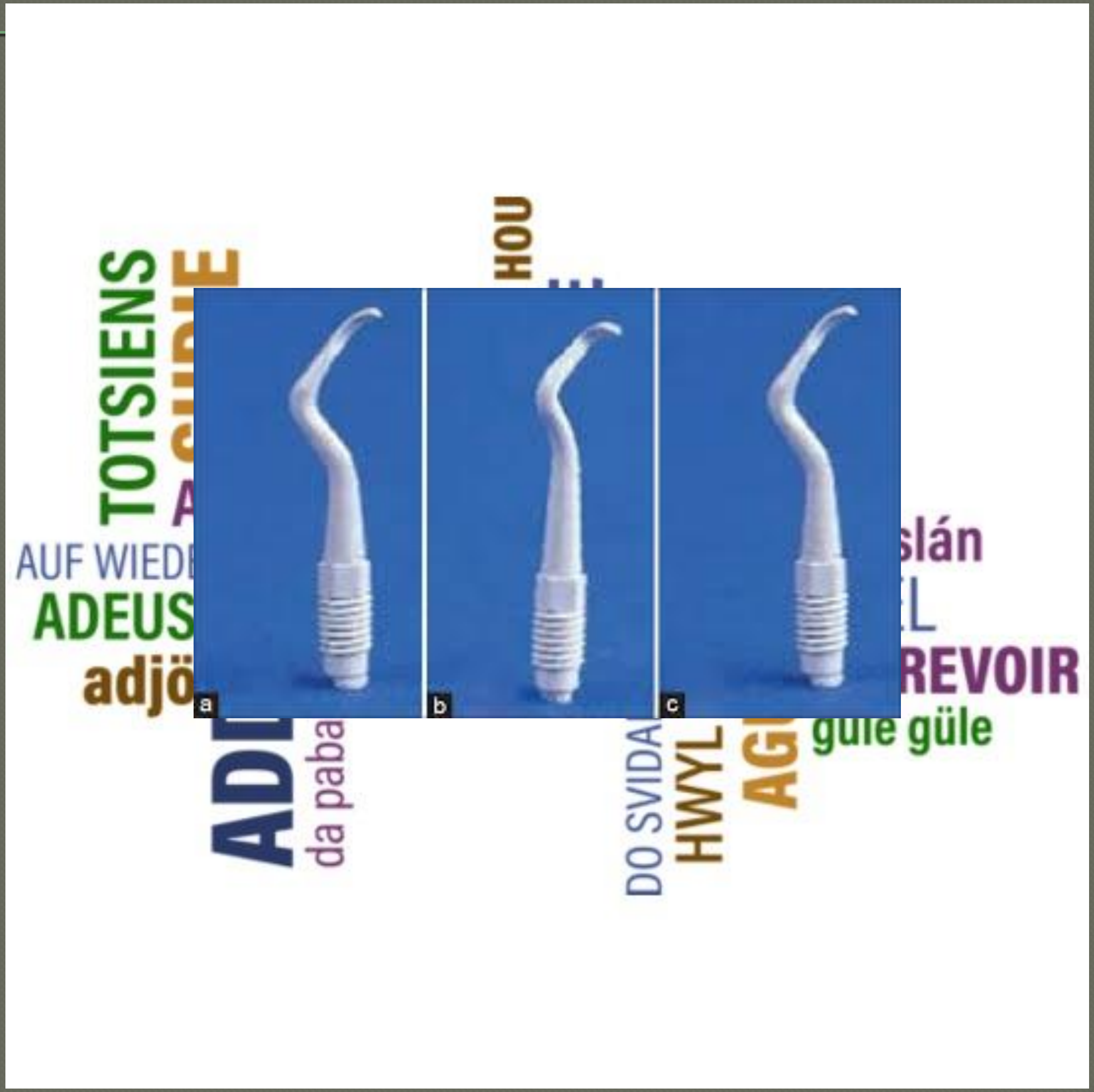
However, studies report that up to 56% of implant patients and even 43% of implant sites can be ailed by the peri-implant inflammatory process, known as peri-implantitis

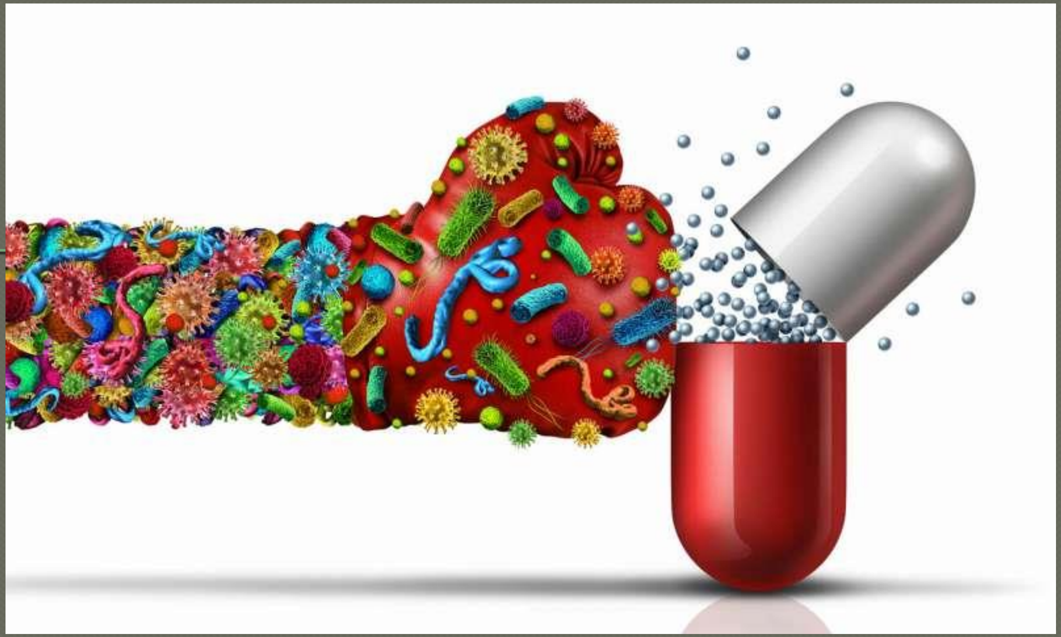
- The basics of peri-implantitis treatment include elimination of inflammation by removing calculus and granulation tissue and decontamination of implant surface without modifying the surface structure.

Mechanical debridement









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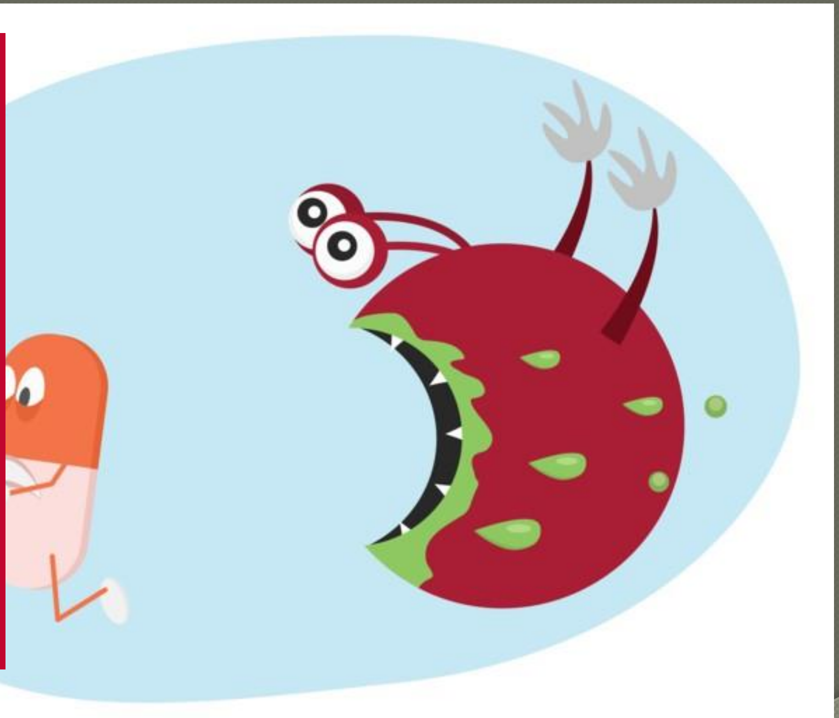
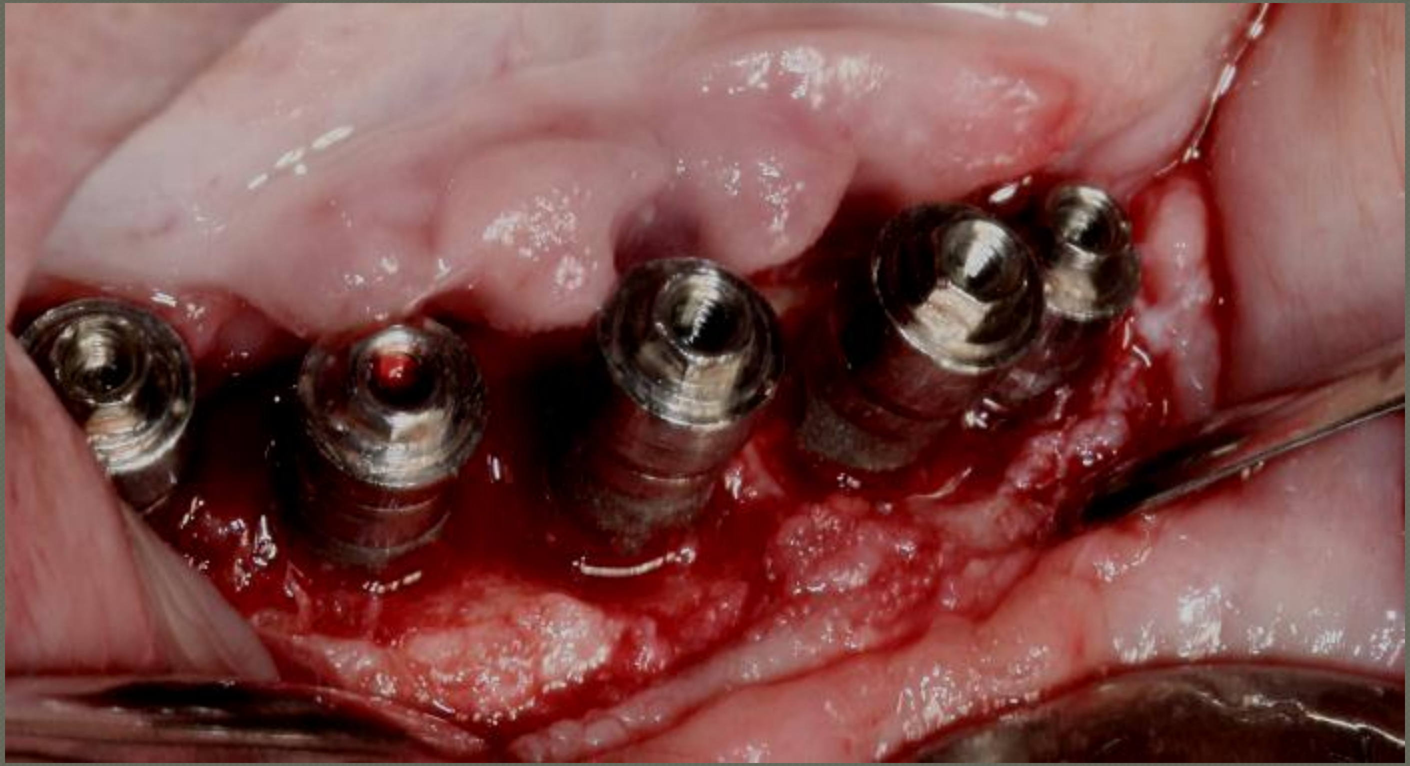
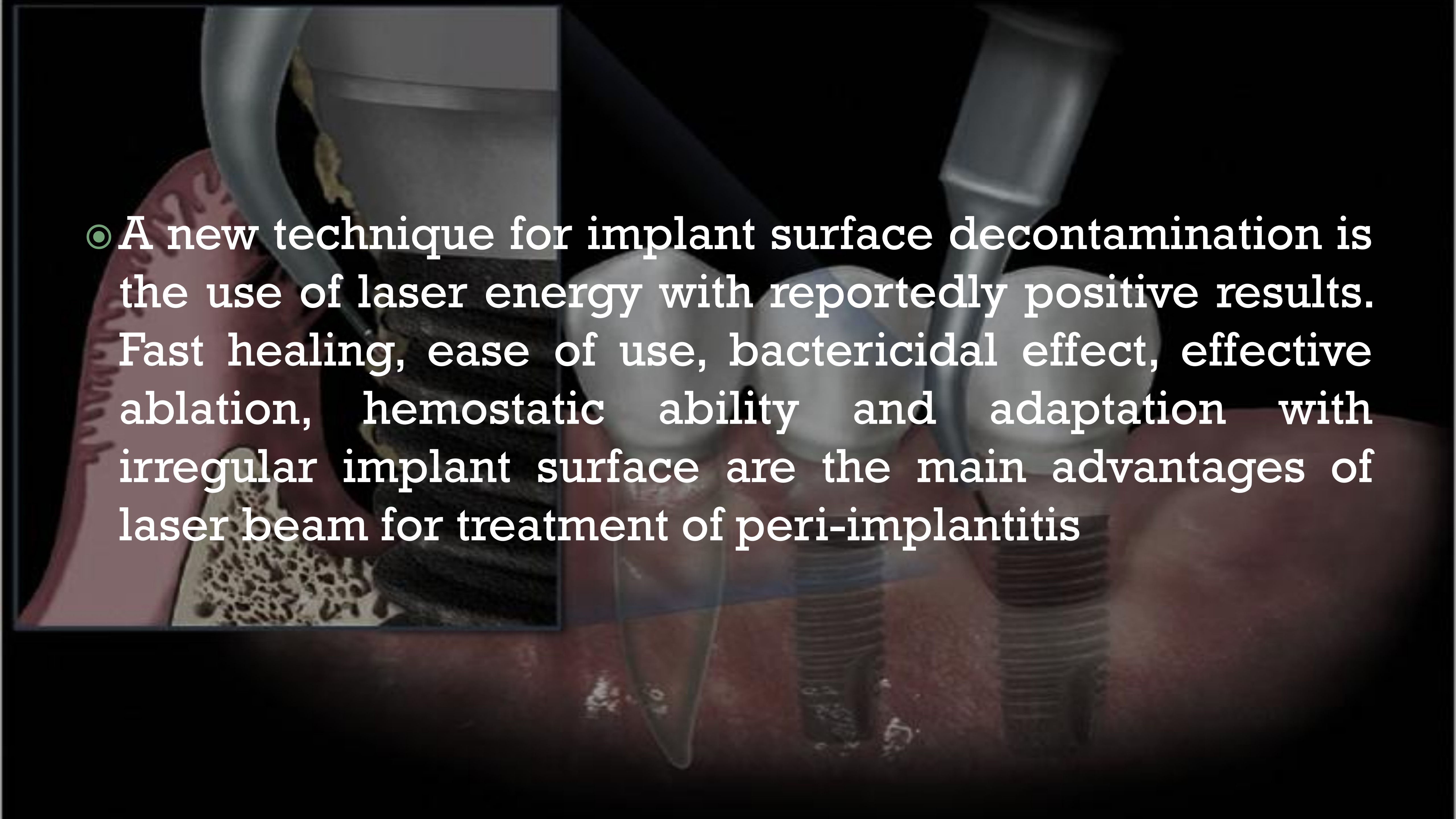


- Surgical treatment may be indicated in cases with severe bone loss and pocket depth greater than 5 mm



- Decontamination of implant surface without damaging it is a prerequisite for regeneration treatments. Mechanical methods alone cannot eliminate all the pathogens on rough surfaces and adjunctive use of antimicrobial agents has been recommended to boost the decontamination efficacy of mechanical methods



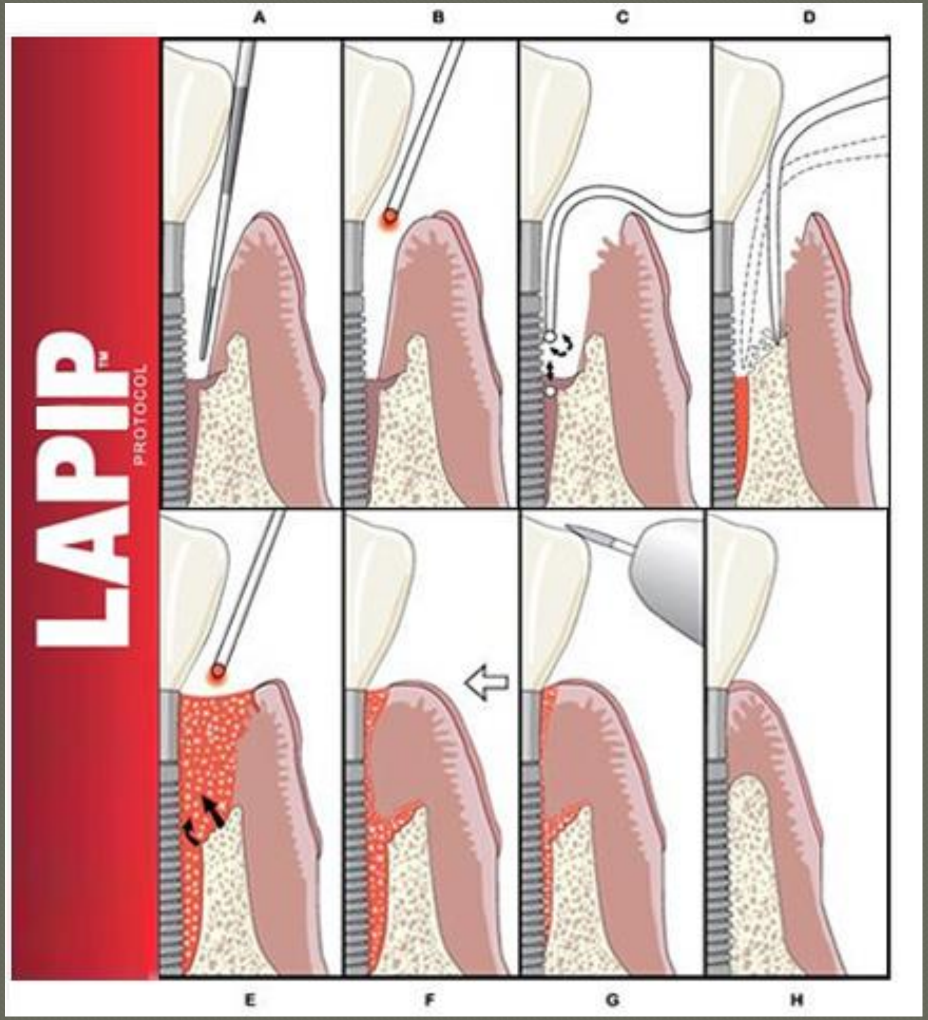
- A new technique for implant surface decontamination is the use of laser energy with reportedly positive results. Fast healing, ease of use, bactericidal effect, effective ablation, hemostatic ability and adaptation with irregular implant surface are the main advantages of laser beam for treatment of peri-implantitis

- Nowadays, a variety of lasers are used in dental procedures as innovative therapeutic techniques that reduce bleeding, swelling, and pain.



LAPIP

Saving Your Failing Implants



Pulsed Nd:YAG Laser Treatment for Failing Dental Implants Due to Peri-implantitis.

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ABSTRACT

A large percentage of dental implants experience complications, most commonly, infection leading to peri-implantitis and peri-mucositis, inflammatory disease involving pathogen contamination. It presents with radiographic findings of crestal bone loss. At this time there appears to be no compelling evidence for an effective intervention. The LANAP protocol is a FDA cleared surgical protocol that produces new attachment and bone regeneration when applied to periodontally infected natural teeth. The LANAP protocol and laser dosimetry have been modified to treat ailing and failing implants. Twenty-one clinicians who have been trained to perform the LANAP protocol and the LAPIP™ protocol have volunteered 26 LAPIP case reports. The time from implant to intervention ranges from 3 months to 16 years. Post-LAPIP radiographs range from 2-48 months. Ten cases were excluded for technical reasons. All 16

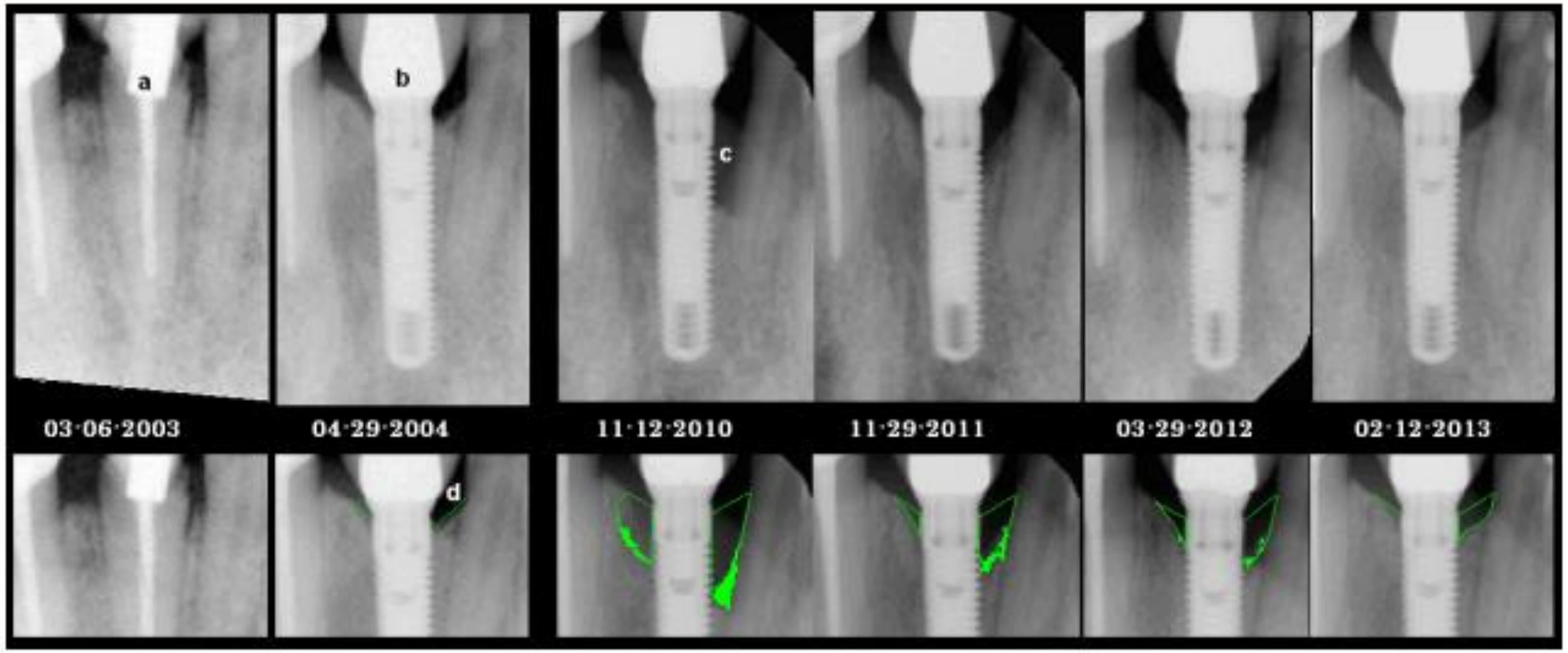


Figure 1. A case of peri-implantitis treated by LAPIP in a 44 year old female. Natural tooth #8 (a) was extracted and replaced with an implant (b) in 2004. In 2010 she presented with peri-implantitis (c) and was treated with LAPIP. The lesion is outlined in the lower panels. The baseline alveolar crest is identified at the time of implant (d). The clusters of green pixels represent pixels with a grey-level value that, in this case, defines the boundary criteria for the edge of the lesion. This case was provided by Dr. Finkbiener.

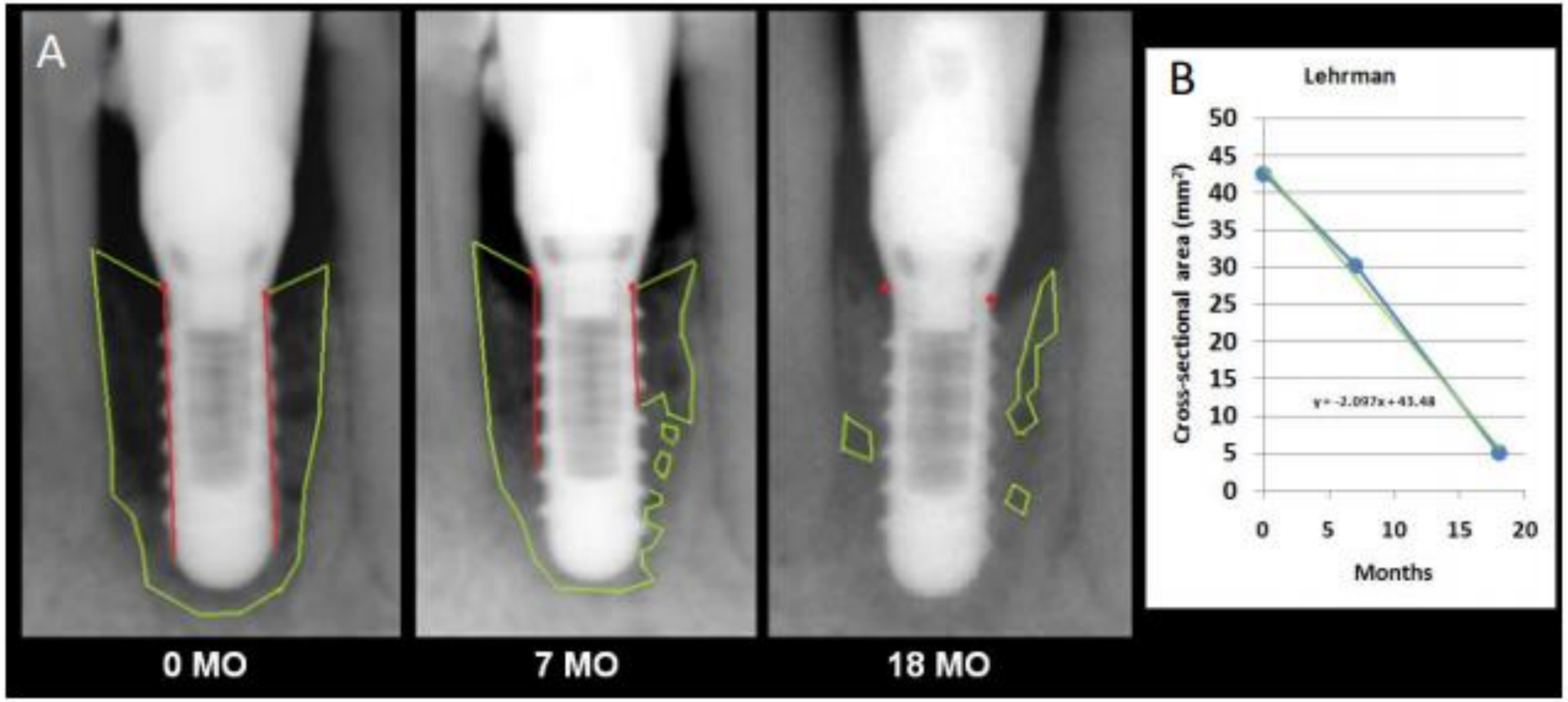
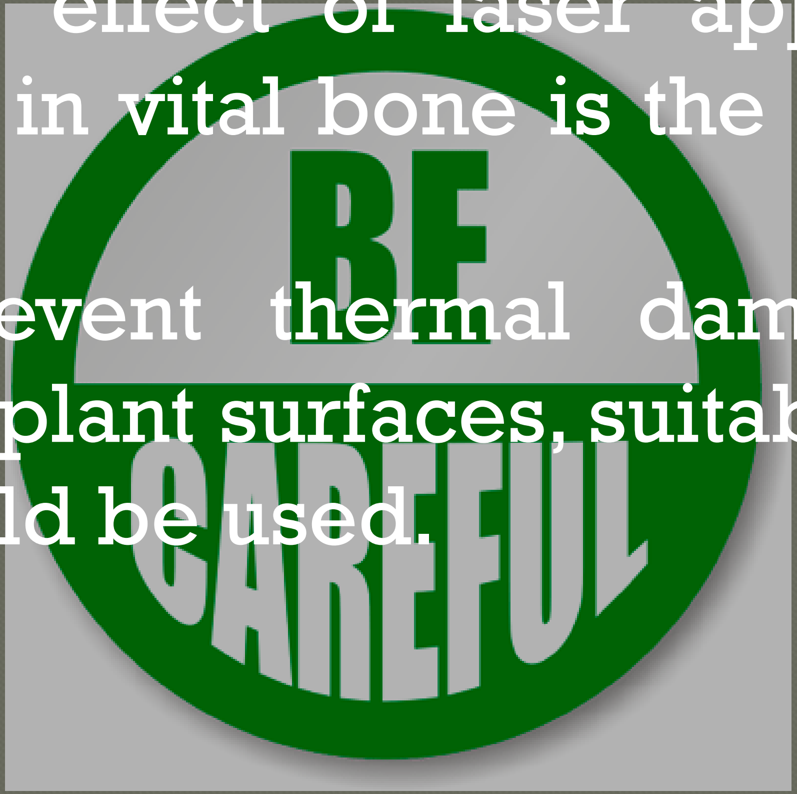
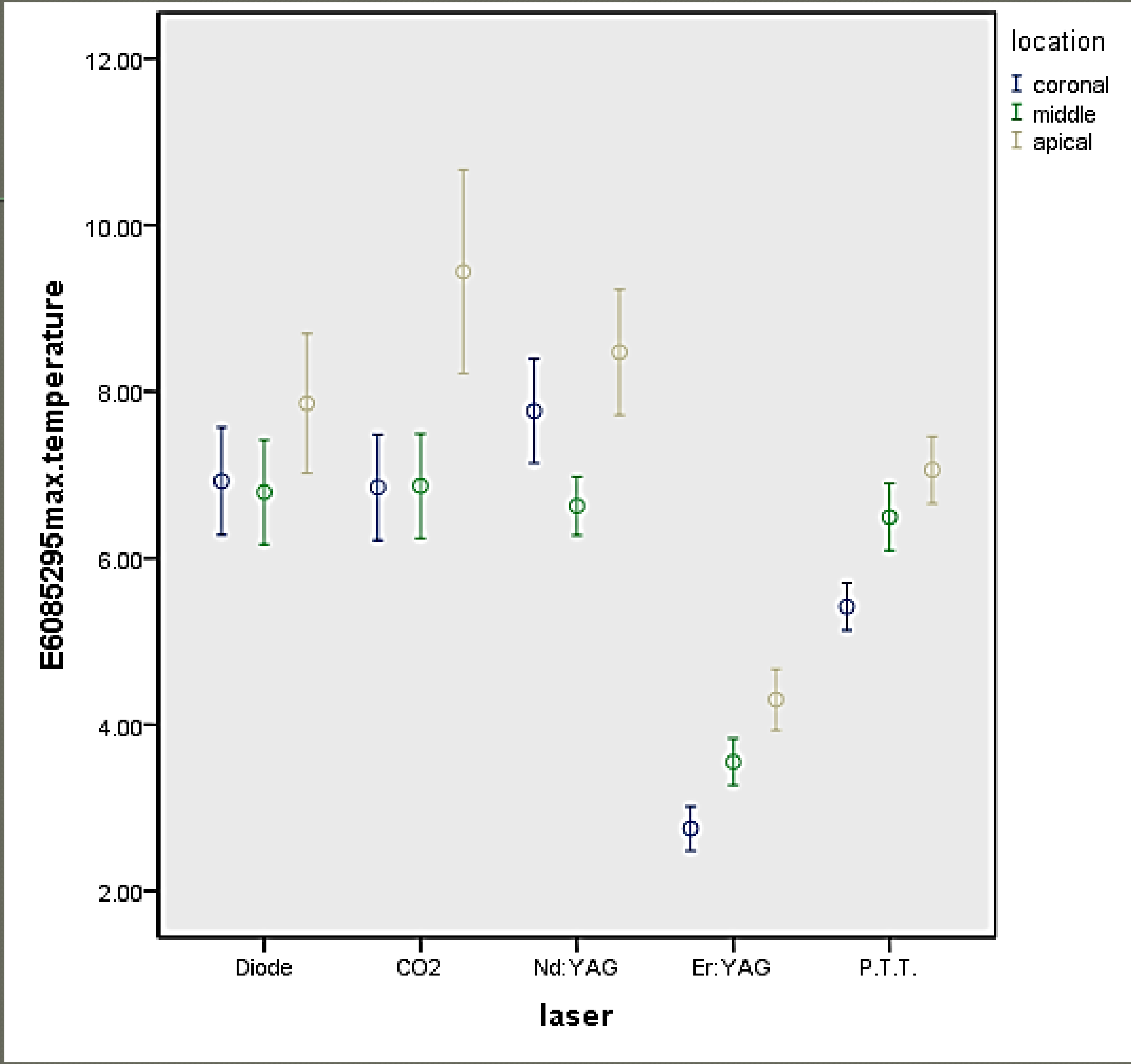


Figure 5. An "extraordinary" LAPIP case provided by Dr. Lehrman. 72 year old male with a four year old implant. (A) A large lesion (43 mm^2) that encompassed the entire interdental space between tooth #23 and #25. One of the most rapid responding lesions. (B) Total lesion area measured with ImageJ VS time post-LAPIP. The linear regression indicates a rate of healing of 2.097 mm^2/month. See text for more details.

- One major side effect of laser application on metal objects inserted in vital bone is the associated thermal increase.
- In order to prevent thermal damage during laser irradiation on implant surfaces, suitable wavelength and parameters should be used.

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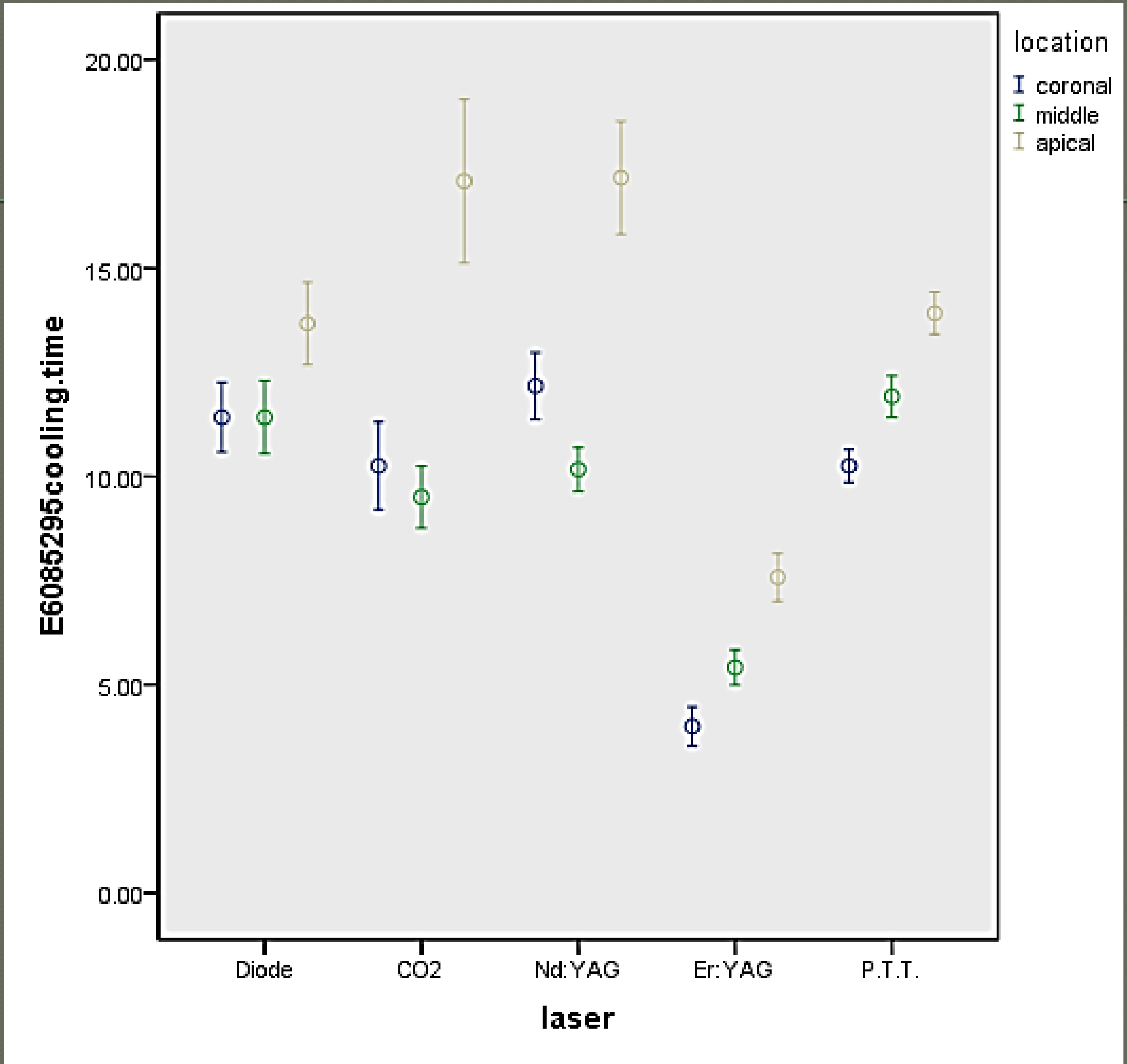
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Photobiomodulation, Photomedicine, and Laser Surgery
Volume 37, Number 8, 2019

Pp. 508–514
DOI: 10.1089/photob.2019.4650

First Investigation of Dual-Wavelength Lasers (2780 nm Er,Cr:YSGG and 940 nm Diode) on Implants in a Simulating Peri-Implantitis Situation Regarding Temperature Changes in an *In Vitro* Pocket Model

Darya Alhaidary, BDS, MSc,[1] Rene Franzen, PhD,[2] Ralf-Dieter Hilgers, PhD,[3] and Norbert Gutknecht, DDS, PhD[1]

Abstract

Objective: This study aimed to investigate the temperature changes and question the safe laser settings and protocols for laser-assisted peri-implantitis treatment in an *in vitro* environment.
Materials and methods: Three types of implants (Neoss, Dentegris, and Camlog) were implanted in an artificial bone model ($n=15$). The model was placed into a 37°C water bath to simulate the *in vivo* oral condition. Throughout the laser irradiation, K-type thermocouples were used to record the real-time temperature measurements at different anatomically important locations in the artificial bone.
Results: In all of the temperature measurements, no temperature rise above the critical safe limit, that is, >47°C, was observed.
Conclusions: Within the limitations of this *in vitro* study, the use of the dual-wavelength protocol [Er,Cr:YSGG (1 and 1.5 W, 25, 50, 75 Hz)] and the 940 nm diode (peak power 2 W, duty cycle 50%) can be considered a safe method in the treatment of peri-implantitis, regarding its thermal safety.

An *in vitro* study by Monzavi et al.[31] aimed to investigate and compare temperature changes during implant decontamination with different laser wavelengths (CO_2, Nd:YAG, diode, Er:YAG laser, and photodynamic therapy). Temperature changes were registered at three points (apical/middle/coronal).

In the entire laser irradiations, the mean temperature changes remained below 10°C. The apical temperature rise was higher than the coronal and middle regions. Temperature changes over 10°C occurred at the apical point of the implants irradiated with the CO_2, Nd:YAG, and diode lasers; however, only the CO_2 laser reached statistical significance ($p<0.05$).

Their findings supported the safety of Er:YAG laser and aPDT in implant decontamination.

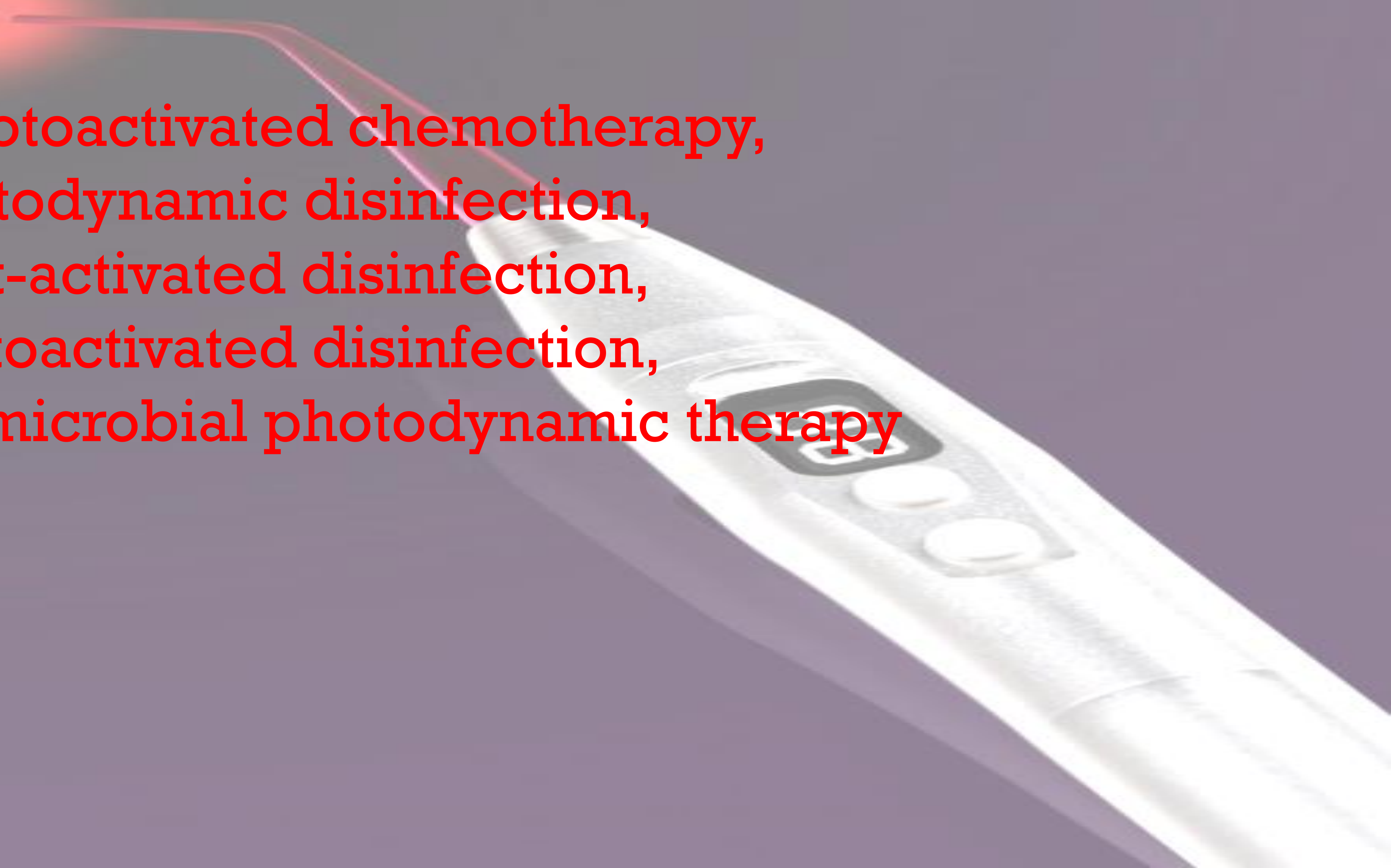
Precaution should be taken in the application of Nd:YAG, diode, and especially CO_2 lasers.

Further, to increase the success rate of laser treatments, several protocols have been suggested using a dual-wavelength 2780 nm Er,Cr:YSGG laser together with the 940 nm diode lasers, combining the disinfection capability of a diode laser and the ablation efficiency of an Er,-

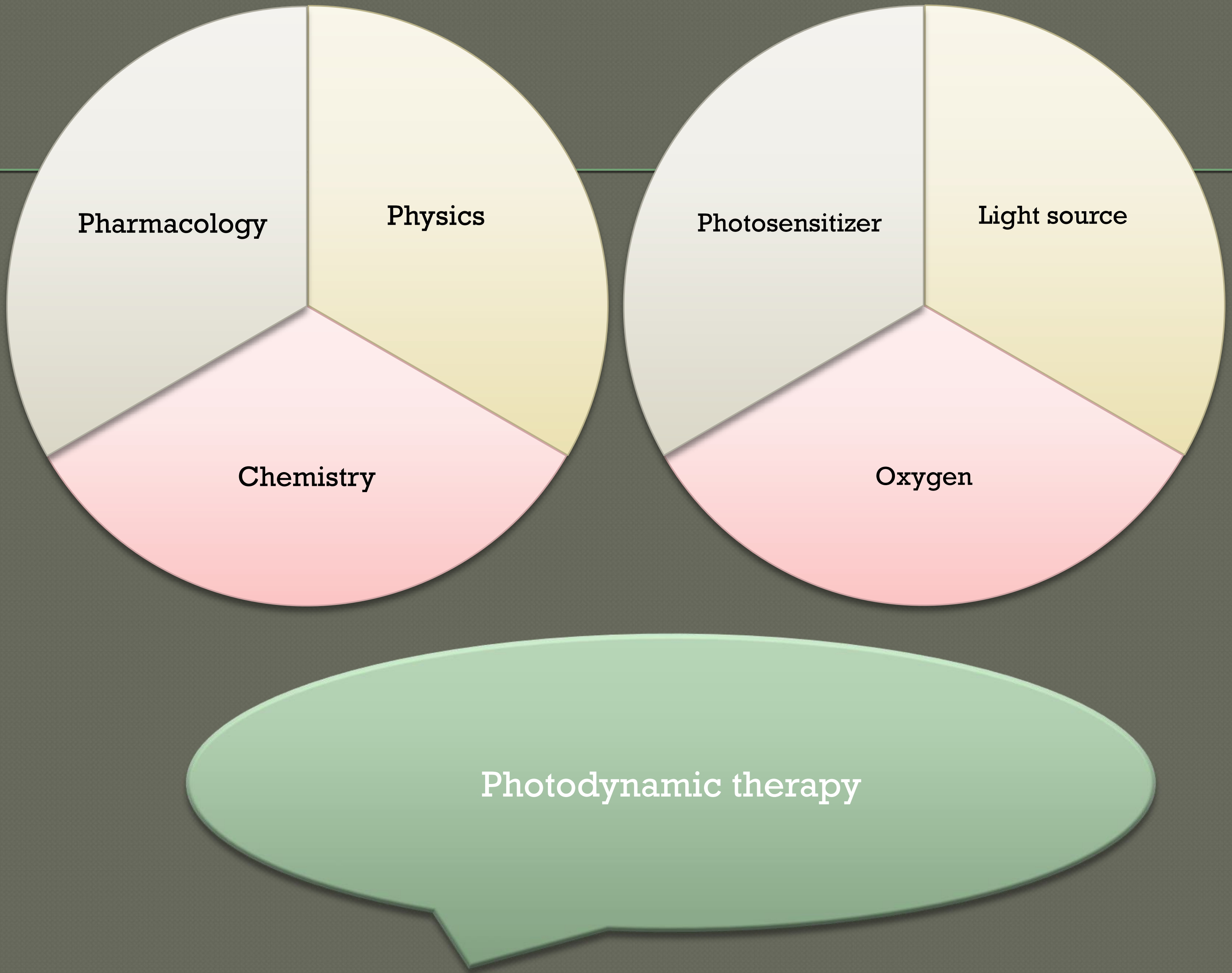
31. Monzavi A, Fekrazad R, Chinipardaz Z, Shahabi S, Behruzi R, Chiniforush N. Effect of various laser wavlengths on temperature changes during periimplantitis treatment: an in vitro study. Implants Dent 2018;27:311–316.

- **Results:** In all of the temperature measurements, no temperature rise above the critical safe limit, that is, >47C, was observed.

Conclusions: Within the limitations of this in vitro study, the use of the dual-wavelength protocol [Er,Cr:YSGG (1 and 1.5 W, 25, 50, 75Hz)] and the 940nm diode (peak power 2 W, duty cycle 50%) can be considered a safe method in the treatment of peri-implantitis, regarding its thermal safety.



- PACT—photoactivated chemotherapy,
- PDD—photodynamic disinfection,
- LAD—light-activated disinfection,
- PAD—photoactivated disinfection,
- aPDT- antimicrobial photodynamic therapy


Pharmacology
Physics
Chemistry
Photosensitizer
Light source
Oxygen
Photodynamic therapy

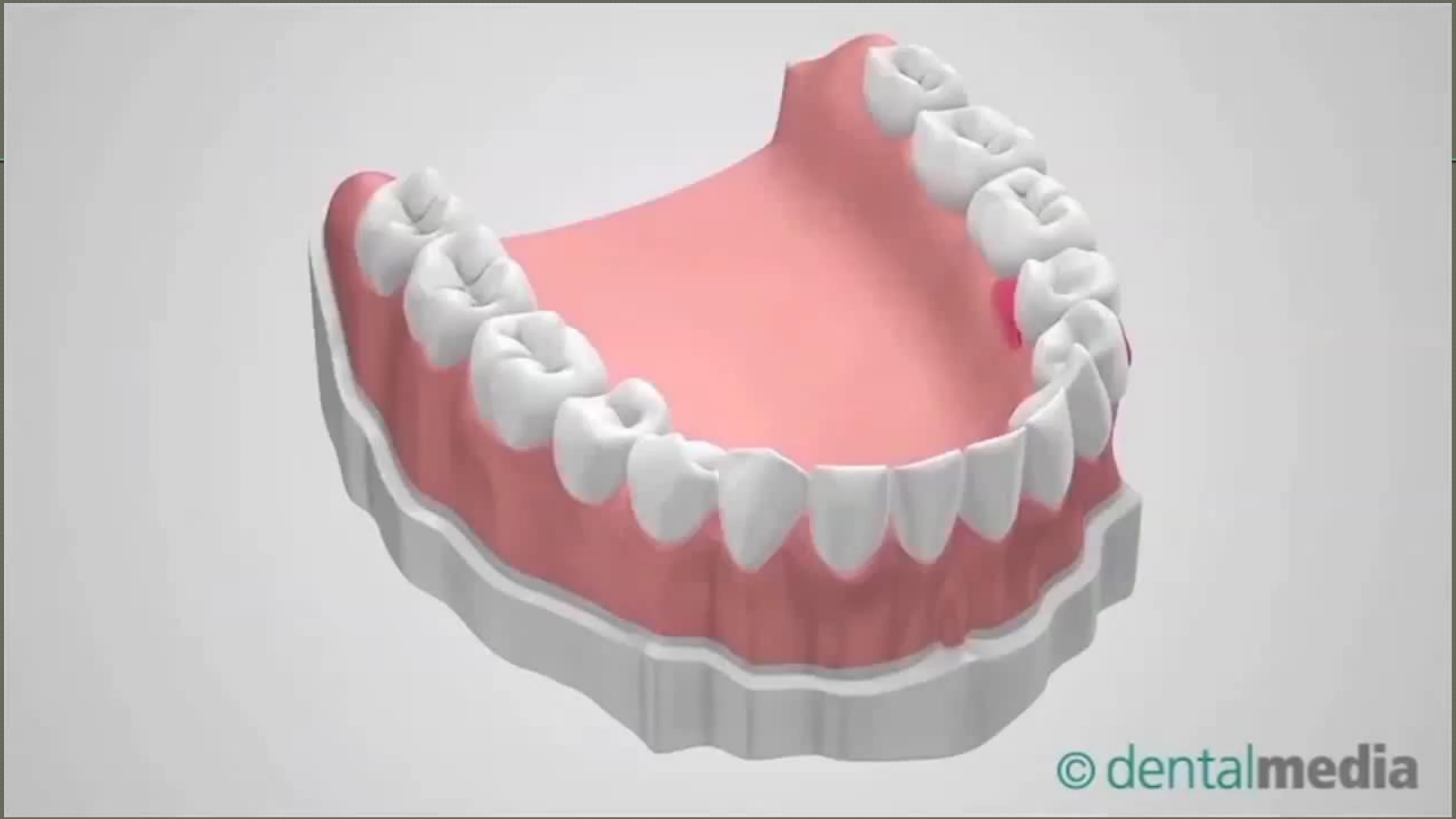
pharmacologically inert chromophore called a photosensitizer

with a low-power laser of an appropriate wavelength

stimulated

reactive nitrogen species (RNS) and oxygen species (ROS), such as superoxide, hydroxyl radicals, and hydrogen peroxide, which are harmful to cell membrane integrity and can cause biological death

harmful to cell membrane integrity and can cause biological death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Photodiagnosis and Photodynamic Therapy 26 (2019) 85–89

Contents lists available at ScienceDirect

Photodiagnosis and Photodynamic Therapy

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ELSEVIER

Antimicrobial efficacy of photodynamic therapy using two different light sources on the titanium-adherent biofilms of *Aggregatibacter actinomycetemcomitans*: An *in vitro* study

Mahmoud Ghasemi[a], Ardavan Etemadi[a,c,*], Mitra Nedaei[b], Nasim Chiniforush[c], Maryam Pourhajibagher[d]

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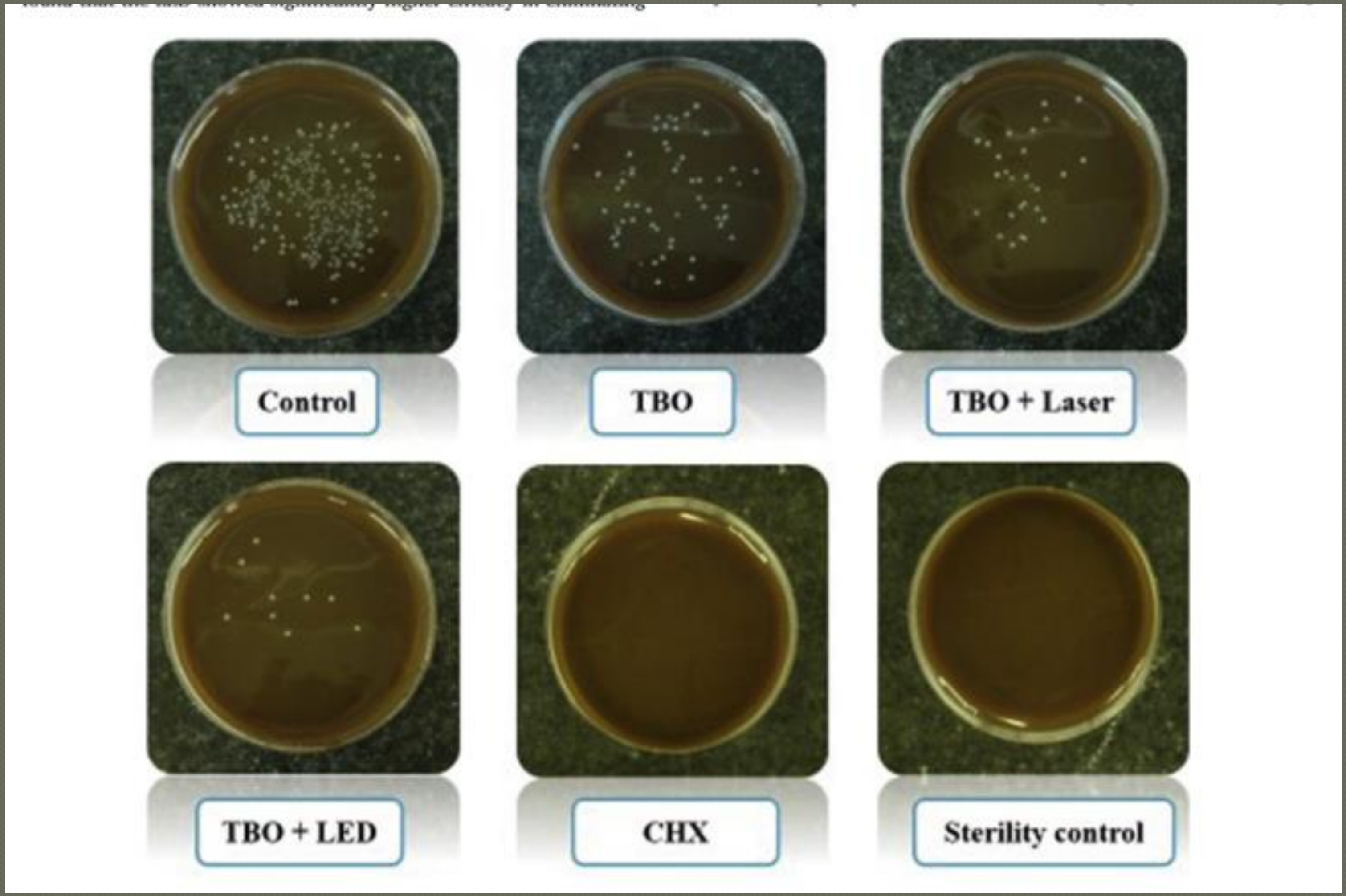
[b] Private Practice, Tehran, Iran
[c] Laser Research Center, Dentistry Research Institute, Te
[d] Dental Research Center, Dentistry Research Institute,

Negative control (no treatment applied), positive control (0.2% chlorhexidine solution), 0.1 mg/mL Toluidine Blue [TBO] group, aPDT-treated groups subjected either to diode laser with a wavelength of 635 nm wavelength or LED with the peak wavelength of 630 nm with TBO as photosensitizer and sterile control (not contaminated).

aPDT using TBO + LED was significantly more effective (0.93 ± 0.24 × 104) in the suppression of A.actinomycetemcomitans compared with TBO + Laser (2.65 ± 0.7 × 104). However, the lowest mean of CFU count was found in sterile, and chlorhexidine groups, respectively (P < 0.0001


Control
TBO
TBO + Laser
TBO + LED
CHX
Sterility control

NCBI Resources How To

PubMed.gov
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Aust Dent J. 2019 Sep;64(3):256-262. doi: 10.1111/adj.12705. Epub 2019 Jun 21.

Adjunctive photodynamic therapy improves the outcomes of peri-implantitis: a randomized controlled trial.

Wang H[1], Li W[1], Zhang D[1], Li W[1], Wang Z[1].

Author information

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Abstract

BACKGROUND: Photodynamic therapy (PDT) can be used for the management of peri-implantitis. This study aimed to explore the efficacy and safety of PDT for peri-implantitis in Chinese Han patients.

METHODS: This was a single-centre, open-label, randomized controlled trial of participants with peri-implantitis treated at the Beijing Chao-Yang Hospital, randomized 1:1 to PDT or no PDT. PDT was performed using toluidine blue (10 mg/mL; 3 min) and a 635-nm laser (750 mW; 10 s/implant side; minimum of 60 mW/cm^2). The primary outcome was the decline in periodontal probing depth (PD) at 6 months. The secondary outcomes were peri-implant plaque index (PLI), sulcular bleeding index (SBI), and clinical attachment loss (CAL).

RESULTS: PD after treatment was smaller in the PDT group (n = 66) than in controls (n = 65) (all P < 0.001 vs. baseline). At 1 month, compared with controls, the PD in the PDT group was larger, while at 3- and 6-month, the PDs were smaller (all P < 0.001). CAL, PLI and SBI in the PDT group was better (P < 0.05 vs. controls).

CONCLUSION: PDT combined with mechanical debridement significantly improves PD, PLI and SBI in participants with peri-implantitis. Importantly, PDT achieved a better CAL than mechanical debridement and cleaning.

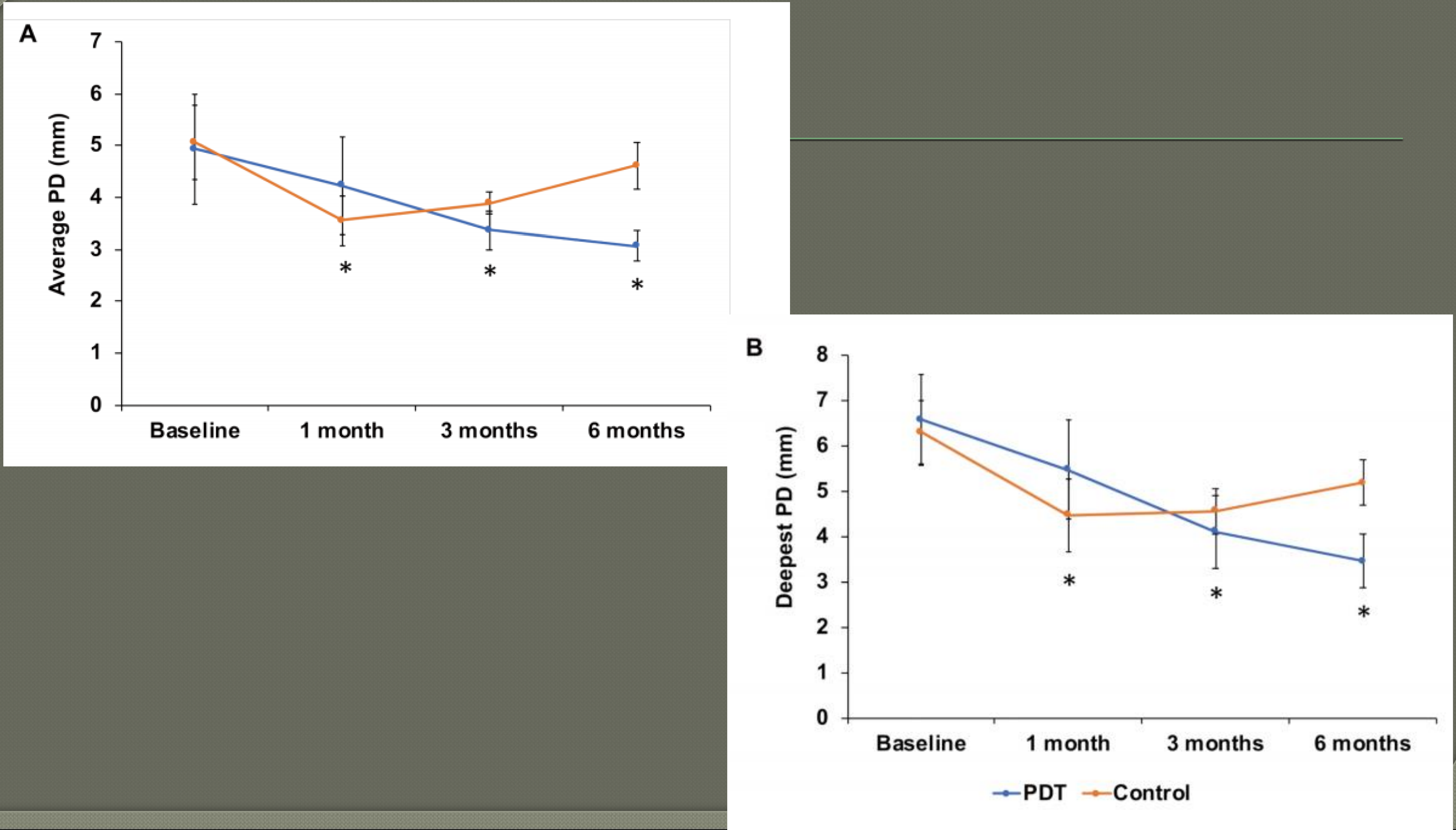
KEYWORDS: Mechanical debridement; peri-implantitis; photodynamic therapy; randomized controlled trial

PMID: 31152567 DOI: 10.1111/adj.12705

at least one implant site with periodontal PD ≥6 mm; visible bleeding around the implant after probing, CAL ≤3 mm;

- with a light-emitting diode (LED) light source (wavelength: 635 nm; power: 750 mW; 3D irradiation; minimum 60 mW/cm2)
- toluidine blue as photosensitizer

CAL, PLI and SBI in the PDT group was better ($P < 0.05$ vs. controls).



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3 months
6 months
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3 months
6 months
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PDT
Control

Received: 13 March 2017 | Revised: 26 April 2017 | Accepted: 26 April 2017
DOI: 10.1902/jop.2017.170172
JOURNAL OF Periodontology

BEST EVIDENCE CONSENSUS

Antimicrobial photodynamic therapy for the treatment of periodontitis and peri-implantitis: An American Academy of Periodontology best evidence review

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[2]Unit of Basic Oral Investigation (UIBO), School of Dentistry, El Bosque University, Bogota, Colombia
[3]Department of Periodontics and Oral Medicine, School of Dentistry, University of Michigan, Ann Arbor, MI
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Email: leandro_chambrone@hotmail.com

Abstract
Background: This systematic review evalua dynamic therapy (aPDT), as an adjunct to non and patient-centered outcomes in patients wi

Methods: Randomized controlled trials (RCT that evaluated mechanical root/implant surf planing [SRP] or implant surface scaling [I the treatment of adult patients (≥ 18 years (CP)/aggressive periodontitis (AgP) or peri-i eligible for inclusion. The MEDLINE, EM searched for articles published up to and inclu analyses were used throughout the review us from baseline), and pooled estimates were e

4 | CONCLUSIONS

Despite the safety and the significant clinical improvements promoted by antimicrobial photodynamic therapy, these gains did not lead to standout additional benefits over traditional forms of treating moderate to severe periodontitis and peri-implantitis.

Within the limits of this SR, based on both individual study outcomes and pooled estimates, it can be concluded that:1) aPDT, when used as an adjunctive treatment, may provide similar clinical improvements in PD and CAL when compared with conventional periodontal therapy in patients with moderate to severe periodontitis. The extension of some statistical gains achieved with the combined therapy does not seem to represent potential clinical relevance. 2) aPDT, when used as an adjunctive treatment, did not show evidence (at this moment in time) of improving the outcomes of implant surface scaling/debridement alone. The extremely limited evidence considered eligible for inclusion in the SR and the impossibility of performing pooled estimates (i.e., meta-analysis) precludes additional conclusions.

and 2) non-surgical treatment of CP using SRP plus aPDT (PD reduction). It might be considered that the extension/clinical significance of additional gains (0.30 to 0.75 mm) promoted with SRP plus aPDT over SRP alone seems imprecise.[59] Such a degree of inaccuracy should be assumed to be due to the small number of studies included within some analysis (non-surgical treatment of AgP patients), differences in study protocols (e.g., SRP and aPDT protocols), and disease severity at baseline (i.e., potential for differing clinical improvements in PD and CAL, favoring deeper sites).[59] Thus, all of these conditions may have impacted the calculation of pooled estimates.

3.1 | Quality of the evidence and potential biases in the review process

Only one RCT[25] was considered to be at low risk of bias, while the other trials were assessed as unclear or as high risk of bias. It should be noted that for most of the trials information on the methods of randomization, allocation, and patient masking were not reported or met. However, the lack of patient masking, per se, did not seem to have interfered in the overall outcomes of each individual trial. Additionally, to reduce potential heterogeneity among studies in terms of combining data from trials with shallow versus deep mean PD baseline values, this SR protocol (inclusion/exclusion criteria) considered eligible for inclusion only reporting PD $\geq$ 5 mm.[59] On the other hand, it may have precluded the inclusion of additional data into the meta-analysis sets.

Also, the degree of heterogeneity identified for some estimates appeared to be linked to the severity of disease (baseline PD), type of mechanical debridement performed, and the type of dye (Tables 1 through 6). The absorption coefficient by the bacteria depends on the photosensitizer and the specific laser wavelength and can have different effects on the periodontal tissues.

More information on aPDT use at periodontitis and peri-implantitis sites would be necessary to allow for a reliable and definitive estimation of effect/magnitude of therapies on health outcomes. It should be highlighted that the reported protocols are quite heterogeneous (i.e., types of dye used, time of laser exposure, power level, diameter of fiber, duration of exposure, whether SRP and/or ultrasonics were used). The calculated meta-analyses provided only a snapshot or bigger picture of the potential role of adjunct aPDT therapy, rather than combining protocols that are fairly similar (i.e., no optimal/gold standard aPDT protocol could be established). Consequently, these conditions should be accounted for when interpreting the results of this SR.

Low level laser

- Therapeutic Laser
- Low Level Laser Therapy
- Low Power Laser Therapy
- Low Level Laser
- Low Power Laser
- Low-energy Laser
- Soft Laser
- Cold laser
- Low-reactive-level Laser
- Low-intensity-level Laser
- Photobiostimulation Laser
- Photobiomodulation Laser
- Mid-Laser
- Medical Laser
- Biostimulating Laser
- Bioregulating Laser

- physiotherapists (to treat a wide variety of acute and chronic muscosceletal aches and pains)
- dentists, (to treat inflamed oral tissues, and to heal diverse ulcerations)
- dermatologists (to treat oedema, indolent ulcers, burns, dermatitis)
- rheumatologists (relief of pain, treatment of chronic inflammations and autoimmune diseases)
- other specialists (e.g., for treatment of middle and inner ear diseases, nerve regeneration)
- used in veterinary medicine (especially in racehorse training centers)
- sports medicine and rehabilitation clinics (to reduce swelling and hematoma, relief of pain and improvement of mobility and for treatment of acute soft tissue injuries)


Konf
KLAS-DX
Introduction

Analgesic effect

Activation of neuron metabolism

↓

Endorphin level growth

↓

Increase of pain threshold

Immune response stimulation

Increase proliferation of immune modifying cells

↓

Accelerate maturation of immune modifying cells

↓

Increase production of immunoglobulins

Wound healing

ATP accumulation		
Activation of cellular metabolism		Increase of proliferation of fibroblasts and other cells
Defective epithelisation	Protein and Collagen synthesis	Capillary formation

Good dentist

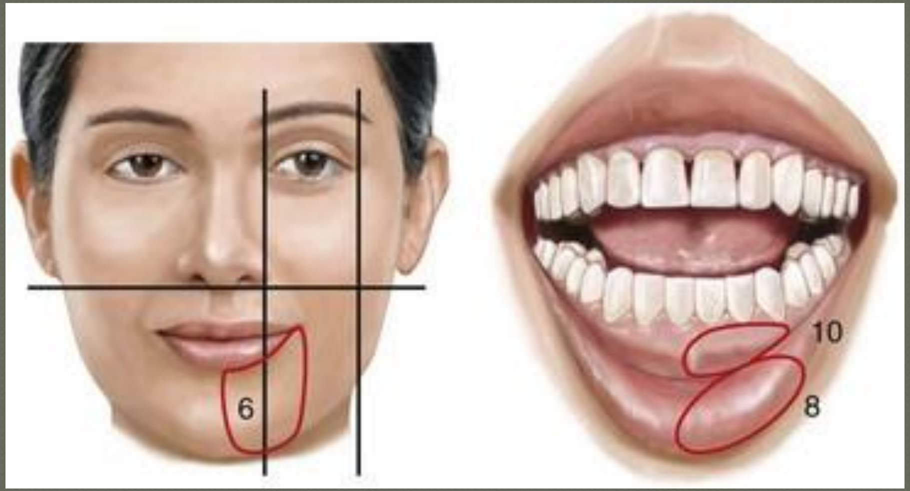
- In the patient's eyes: one who does not inflict pain either during or after treatment.
- Even if we can not always fulfill these desires we should at least be able to make use of all available means of reducing the number of occasions on which our treatment causes pain.

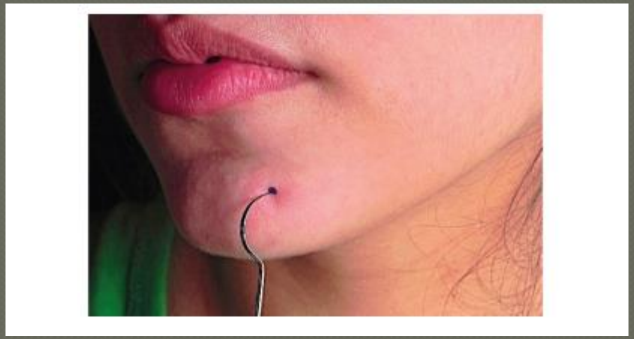
Remember

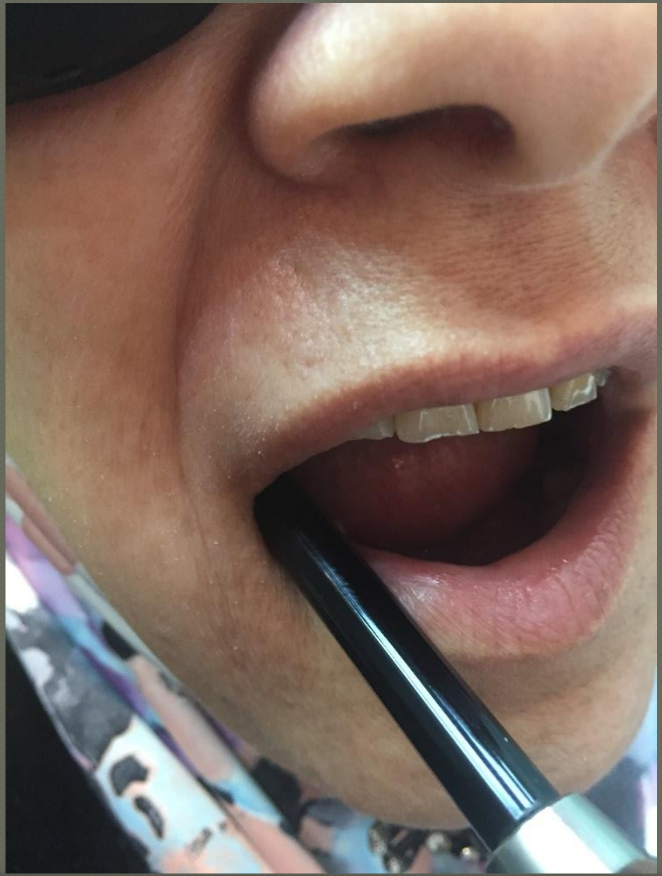
- Not all patients react in the same way to laser therapy , depending on the condition of the tissue and immune system.
- Example: anesthetic injections

Paresthesia

- Suggested laser protocol: red or infrared
- laser



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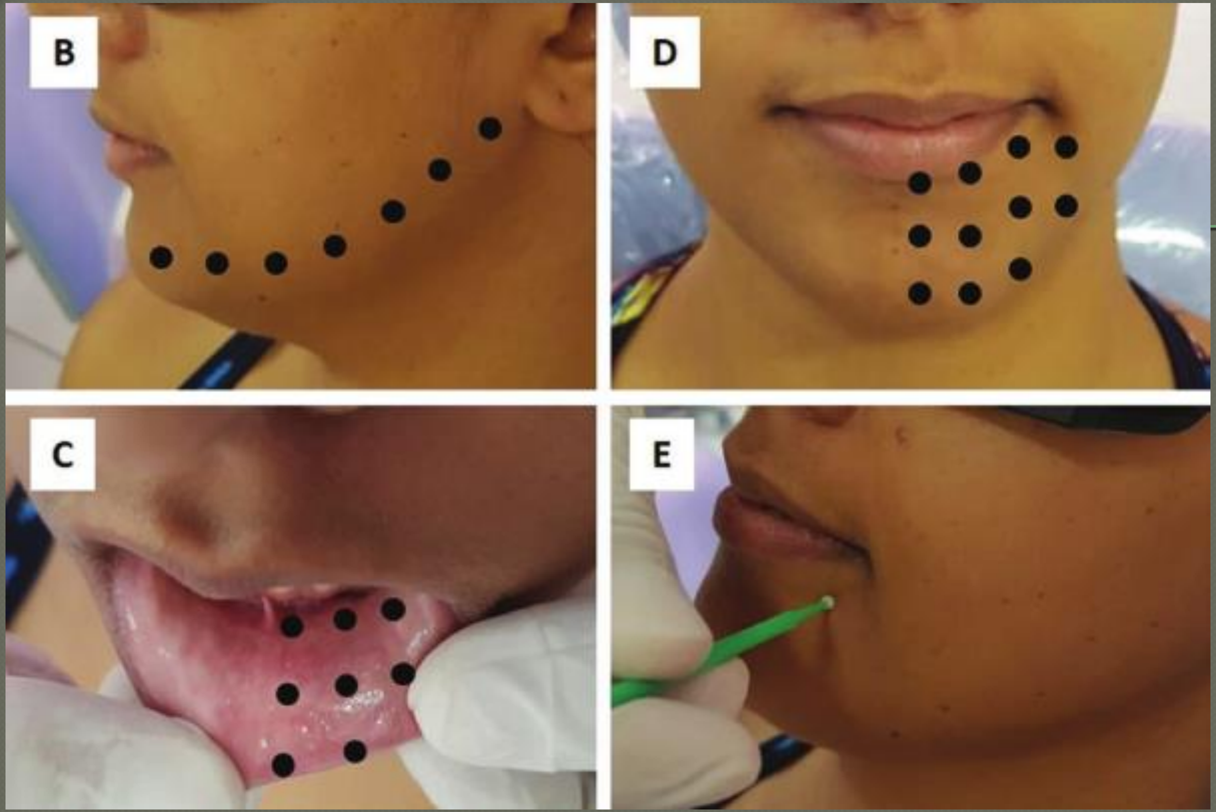
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