
# JLAD
JOURNAL OF LASER-ASSISTED DENTISTRY


## THE TIME HAS COME

Is This the End of Passive Ultrasonic Endodontic Irrigation?

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2022 | Issue 5

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# INSIDE ISSUE 5 2022

# EDITORIAL

## VICTORY THROUGH PERSISTENCE

The only way to describe the past 12 months in all our lives would be **CHALLENGING**. We came out of COVID-19 isolation victorious, some of us had to adjust to fallow times and wearing excessive PPE, others had to deal with staff shortage and delays in the supply chain, but we all came together and supported one another. Although, the pandemic does not seem to be over, we are no longer afraid to live our lives as normal as possible, travel, meet friends and colleagues and share knowledge. For the first time in two years, we finally met for a live in-person symposium. WCLI 2021 in Dubai was a huge success with attendees from more than a dozen countries, nine amazing speakers sharing their knowledge in various fields of Laser Dentistry. We are happy to welcome more than a hundred new Associate Fellowship members to the WCLI family and I hope that the thirst for knowledge will lead them towards more advanced certifications and deeper understanding of all the benefits lasers bring to the patient care and practitioners self-satisfaction alike.

I would like to congratulate Beata Knysak (UK) and Dr. Mircea Ioana Laura (Romania) for passing their Fellowship level certification, they both worked very hard and made us proud. We also welcome 4 new Mastership certificates to the WCLI family, These accomplished individuals are Dr. Yuliya Kozlova (Russia), Dr. Ariel Savion (Israel), Dr. Saleh Anvaria-Aria (UK) and Dr. Isaac Kably (Mexico). I would also like to thank Dr. Premilla Suganthan (India) for missing many wonderful presentations during the Symposium in order to administer oral examinations and case presentations for our fellowship and mastership applicants.

European Forum in beautiful Barcelona after numerous cancellations and delays finally happened and reinforced the importance of getting together and sharing knowledge through "Education, Fellowship and Fun". 10 speakers from Europe, Canada, US, Israel, Egypt, Mexico and Australia volunteered their time and expertise, for which we are entirely grateful. I feel blessed to share my passion for laser dentistry with these distinguished individuals, many of which after many years I would call my friends. I would like to encourage new members to attend future forums and symposiums, come up to the speakers, doctors wearing Fellowship and Mastership badges, introduce themselves, start conversations, ask questions because just as much learning happens during coffee breaks and informal chats as from listening to the speakers presenting on the podium.

JLAD is a laser dentistry journal for WCLI community written and published by WCLI community. It is the platform where you will find the latest important research publications, interesting case reports from fellow members as well as meet the Masters from all over the world. I am very excited and proud to be able to revive this initiative and continue bringing you JLAD every year, with your help, of course.

Marina Polonsky, DDS, MSc.

**DR. MARINA POLONSKY**
EDITOR

Dr. Polonsky holds a Mastership with WCLI, Master of Science in Lasers in Dentistry degree from RWTH University in Aachen, Germany. She is a recipient of Advanced Proficiency and Mastership Certificate with ALD (Academy of Laser Dentistry) and is a recognized member of the ALD Speaker Bureau. She is a founder of the Canadian Dental Laser Institute (CDLI), ALD affiliated international study club.

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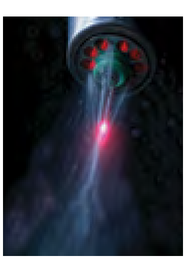

### COVER IMAGE

Member-submitted macro image of them firing the Er,Cr;YSGG all tissue laser.

PHOTO CREDIT:
**Dr. Santosh Patil**
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# THE TIME HAS COME

## Passive Ultrasonic Irrigation Techniques to be Replaced by Laser Photo-acoustics in Root Canal Treatment.

*By Fernando J. Meza, DMD*

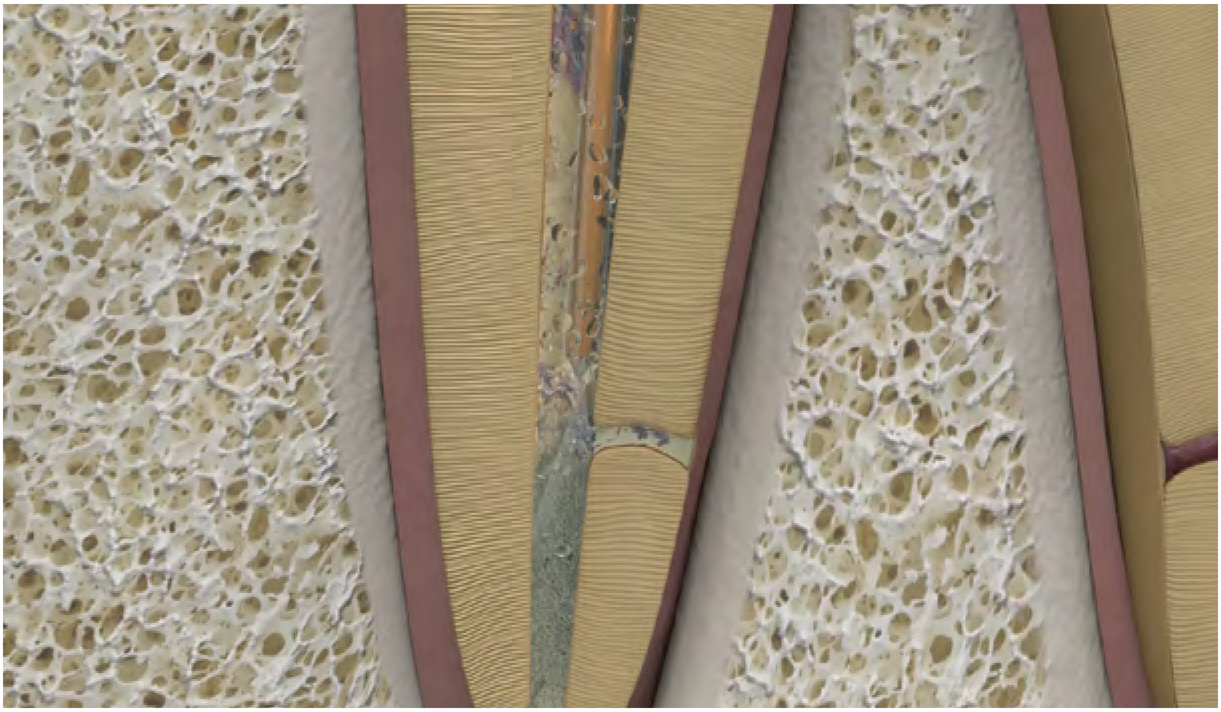
## INTRODUCTION

We have all been there before, at some point in our career when we realize we are missing the right tool for the job. Whether it's working on a house project, cooking a meal or, as dentists, operating on teeth. Lasers have been around for many years in medicine and dentistry however, yet we are finally realizing they are optimal in many clinical applications. In this article, I want to demonstrate how the Waterlase iPlus All-Tissue Laser (Er,Cr:YSGG), by Biolase is the right tool for root canal debridement and disinfection in our lifelong pursuit of the treatment of apical periodontitis.

It is always tempting to directly apply results from studies to real life. However, it may take years to develop adequate models that help us bridge the causal connections we are trying to establish. Materials and methods are everything in scientific studies. Different conclusions may emerge depending on how experiments are constructed. As they say: "the best test is the test, that tests". What this means is: what if the methods applied do not accurately reveal what we are looking for? This was apparent decades ago when only culture-dependent methods to detect pathogenic organisms inside infected root canals were used. More recently, newer molecular approaches involving PCR sequencing reveal hundreds of more pathogenic bacteria that we never knew were present inside the infected root canal space. [1] As we turn to lasers now, we will discuss how several studies conducted on enhanced canal debridement and disinfection utilizing ultrasonics are not keeping up with lasers and recent goals in root canal treatment.

## PASSIVE ULTRASONIC IRRIGATION VS. LASERS

Let us discuss how lasers can make our lives easier in terms of debridement and disinfection of the root canal system in treating apical periodontitis. Ultrasonic and



endosonic devices have been tried in the past using different levels of oscillating frequencies applied to tips or files. Many studies show that ultrasonics are capable of acoustic streaming and cavitation effects as the tip is allowed to oscillate to its greatest potential in a water tank. However, when the same tip is placed in a confined root canal space, where oscillations are diminished and energy is dissipated against the canal walls, a different picture emerges. [2-6]

Although passive ultrasonic irrigation techniques have proven useful in debridement and disinfection of the root canal system, there are several limitations. We will discuss these limitations but first, let us describe the two main types of passive ultrasonic irrigation techniques: continuous and intermittent. The continuous version is when you are continually supplying the canal with either water from the active ultrasonic device or your irrigating solution of choice, which usually turns out to be sodium hypochlorite. The intermittent version is when you flood the pulp chamber or canals with water or irrigating solution, pause, then activate the oscillating ultrasonic tip inside the chamber or canal, and then repeat the cycle.


One example of continuous passive ultrasonic irrigation that incorporates the ultrasonic tip and delivery of solution in one complete mechanism is the ProUltra PiezoFlow system (by Dentsply Maillefer). By attaching a syringe to the specially designed tip, sodium hypochlorite solution can be directly injected into the canal at the orifice or root level that is 1 mm from binding to the canal wall while at the same time, the tip is made to oscillate. The tip size is equivalent to a #50 file and therefore an apical preparation of a size #40 0.04 taper is necessary.[7, 8] If using the intermittent technique, syringe irrigation is used to replenish the irrigating solution in between cycles of the oscillations. Studies have conflicting results between the effectiveness of different types of passive ultrasonic irrigation techniques.[9]

One serious limitation to most of the in vitro and in vivo studies conducted with passive ultrasonic techniques is that the apical preparation size must be quite large to allow the full displacement amplitude of the oscillating ultrasonic tips.[1-5] Apical sizes ranging between #50 0.02 taper, #40 0.04 taper, or #30 0.06 taper are often cited as necessary to achieve the space for the tip to oscillate and cause the shear forces necessary to enhance debridement.[2-8] These sizes are needed for both types of passive ultrasonic irrigation techniques including intermittent and continuous versions with or without the use of the PiezoFlow system.[7, 8] One has to wonder whether it is always possible to instrument large to these sizes without causing ledges or transportation of the canal walls.

Another limitation to consider is the study design whereby closed or open systems are evaluated in apices and isthmuses since these opposing systems greatly affect the results of cleanliness.[7, 8]

In addition to canal preparation size, ultrasonic tip size, and efficiency of energy transfer, the direction of the oscillating tip within the canal space has an effect.[10] Applying the correct direction of oscillation displacement may prove difficult to orient and control during use on a patient. While energy settings are easily controlled on the laser unit, ultrasonic settings may sometimes be too high for use inside the root canal space or just not as effective in terms of amplitude displacement.[6] When laser fiber tips are used, orientation does not matter and contact with the canal walls does not dissipate the photo-acoustic streaming and cavitation effect.

Duration of treatment time with ultrasonic devices is also a factor. Passive ultrasonic studies will often mention a treatment time of 1 to 3 minutes using ultrasonic tips.[7-9] As a comparison, laser studies often will mention 20-30 seconds of treatment time. [11-13]

Another grave limitation of passive ultrasonic irrigation is whether cavitation is actually observed within the root canal space. Acoustic streaming which encompasses fluid velocity and turbulence is the main effect achieved from ultrasonic tips. Cavitation, which is the formation of bubbles within the fluid in the canal that rapidly expand and implode causing jets and shear forces, is not as readily observed in ultrasonics.[2-6] When a laser tip is activated in water or an irrigating solution within the root canal space or a small glass cylinder, a powerful cavitation effect occurs.[14-16] This phenomenon is termed photoacoustics whereby the laser tip can efficiently convert light energy into powerful mechanical pressure waves capable of bubble formation, expansion, and implosion. It is precisely when the bubbles collapse that jets are formed that translate into shear forces. Within a confined root canal space, these formed cavitation bubbles can produce a pressure gradient that results in a fluid pump.[14] It is this photo-acoustic effect producing both acoustic streaming and cavitation within a confined space that facilitates root canal debridement and disinfection when lasers are used.



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Please refer to your laser user manual for specific instructions and indications for use.

In cases where root canal anatomy should be conservatively maintained and maximum apical sizes of #20 0.07 taper preparation or smaller are ideal, the acoustic streaming or cavitation effect is quickly dampened as the ultrasonic file contacts the root canal wall.[17] Instead, a final apical preparation size of #40 0.04 taper or a #30 0.06 taper is advocated for proper use of passive ultrasonic irrigation techniques.[2-8] This is not the case with laser fibers, particularly when using the Waterlase Er,Cr:YSGG 200 micrometer radial firing tip. Although the tip may be small enough to reach working length in some cases, current protocols with the laser show that considerable acoustic streaming and cavitation at the apical region is still achieved while the fiber tip remains either at the mid root, orifice, or pulp chamber.

An important distinction between ultrasonics and lasers that I am expressing in this article is that root canal preparation size may not be relevant since the photoacoustic effect is not dissipated when the laser fiber tip encounters the canal wall. The obvious question to ask is: "Can the original anatomy of the root canal space be respected or, at least, can a conservative enlargement of it be sufficient to address our goals of treating apical periodontitis?"

I present to you a case using the Waterlase iPlus with the RFT2 (200 micrometer, radial firing tip) by Biolase. Pre-operative, immediate post-operative, and 10-month follow-up periapical images of a tooth #30 (#46 international), necrotic pulp with symptomatic apical periodontitis, completed in one visit, are shown. Powerful acoustic streaming and cavitation effects at the apices of this tooth which allowed for optimal canal debridement and disinfection, in my opinion, would not be possible without the use of the laser.

## CONCLUSION

As dental practitioners, we need to have all the right tools for our patients. We can't decide to use the microscope on one case and not on another or decide not to purchase a CBCT because it is not needed in every case. The same can be said about canal debridement and disinfection as it relates to apical size. If I have a large canal, I will reach for the ultrasonic unit, if not I will reach for the laser. The value of the laser in endodontics is that it can be used effectively in all cases with large or small apical sizes in less treatment time. Other benefits with lasers include soft tissue management with less bleeding in gingivectomies and apical surgery. The ultrasonic unit is a wonderful tool, and it too has its place for conservative removal of dentin to find canals, and for gutta percha and post removal. In terms of root canal debridement and disinfection, however, it's time to retire the ultrasonic unit and the passive ultrasonic irrigation techniques and allow the incredible power of photoacoustics as mediated by the Waterlase All-Tissue Laser to take a front row seat. ■

## About *the Author*

**Fernando J. Meza, DMD**

Dr. Meza is a 2002 graduate of the University of Connecticut School of Dental Medicine. He is a recipient of the AADR/Dentsply Sirona sponsored Student Clinician Award. Dr. Meza received his Certificate in Endodontics from Temple University School of Dentistry in 2004. During his residency, he conducted research on the Biolase Waterlase All-Tissue Laser to explore the disinfecting capabilities of the laser on bacterially infected root canal systems. His research led to a publication in the Journal of the American Dental Association in 2007. He has been in private practice in endodontics in Northern Virginia since 2004. He has also volunteered as Assistant Clinical Professor of Endodontics at the University of Maryland School of Dentistry as part of the Dean's Faculty from 2005 - 2017.

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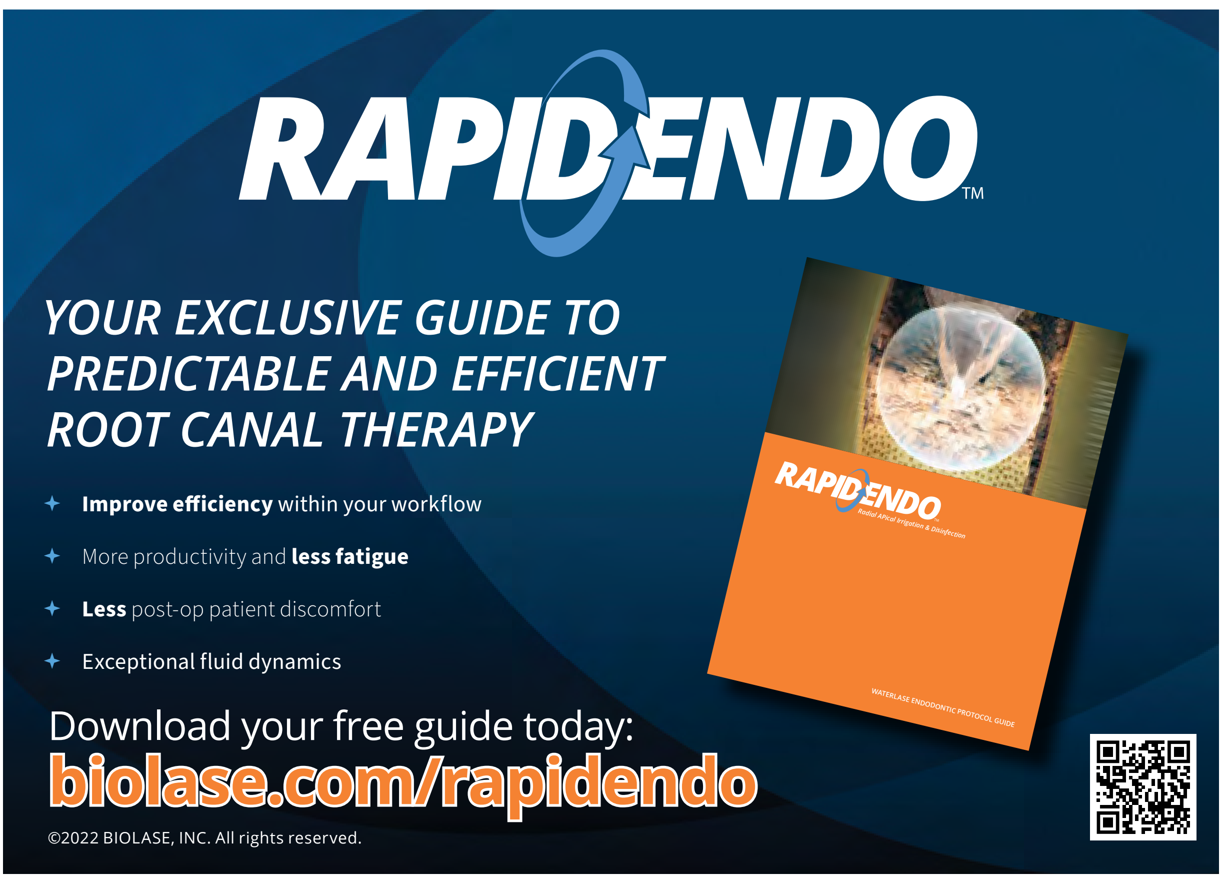

# A CLINICAL LOOK

## *Treatment of Recurrent Aphthous Stomatitis with Er,Cr:YSGG Laser Irradiation: A Randomized Controlled Split Mouth Clinical Study*

Hasan Guney Yilmaz [a,*], Mohammed Rateb Albaba [a], Ayse Caygur [a], Esra Cengiz [b], Fatma Boke-Karacaoglu [c], Hayriye Tumer [a]

a Department of Periodontology, Faculty of Dentistry, Near East University, Mersin, Turkey;
b Department of Restorative Dentistry, Faculty of Dentistry, Mersin University, Mersin, Turkey;
c Department of Periodontology, Faculty of Dentistry, Ankara University, Ankara, Turkey

Journal of Photochemistry & Photobiology, B: Biology 170 (2017) 1–5

## METHODS AND MATERIALS

This randomized controlled split mouth study investigated the use of erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser on pain reduction and healing rate of recurrent aphthous stomatitis (RAS). Forty patients were recruited with inclusion criteria as a chief complaint of minor RAS lesions in the buccal or labial non-keratinized mucosa for 3 days or less. Exclusion criteria were systemic conditions pre-disposing the patients to RAS, herpetic lesions, traumatic ulcers, ulcers caused by topical or systemic mediations, or at the time of the study undergoing systemic or local treatment for RAS. For each patient, 2 lesions were selected in different parts of the mouth; one lesion was treated with a Er,Cr:YSGG laser on hard tissue mode using a mg6 sapphire tip at an energy level of 0.25 W without water and the other lesion was treated with the same protocol without laser emission. All treatments were performed by the same investigator at one visit and later scored the healing of RAS (HRAS) lesions on a 4-point scale: (1) complete healing, (2) moderate healing with >50% of the lesion healed, (3) slight healing or <50%, (4) no healing. Treated subjects rated their healing on a pain visual analog scale (VAS) immediately after treatment, day 1, 3, 7, and 10.

## RESULTS

All 40 participants in the study completed the 10-day test period. Mean scores of VAS and HRAS were calculated:

**Table 1 for VAS:** The test group (lesion that received laser irradiation) showed significant pain reduction at baseline compared to the non-irradiated group (placebo). This effect was maintained throughout the study, whereas the placebo group showed no statistically significant differences in pain reduction immediately after treatment, day 1 and day 3. The opposite was found for the group that received laser irradiation.

**Table 2 for HRAS:** Similar findings for healing were found and were statistically significant at days 3, 7, and 10. Differences between VAS and HRAS scores were found for all control days except for day 10, according to the intergroup comparisons.

**Table 1**
Mean degree of VAS scores and standard deviation in both groups over 10 days.

| | Baseline | Immediate | Day 1 | Day 3 | Day 7 | Day 10 |
|---|---|---|---|---|---|---|
| Laser | $8.3 \pm 2,1^{a}$ | $0.2 \pm 0.5^{b,*}$ | $0.8 \pm 0.6^{b,*}$ | $0.4 \pm 0.2^{b,*}$ | $0.1 \pm 0.3^{b,*}$ | $0.0 \pm 0^{b}$ |
| Placebo | $8.1 \pm 2.4^{a}$ | $7.8 \pm 2.1^{a,*}$ | $7.4 \pm 1.8^{a,*}$ | $4.7 \pm 1.6^{b,*}$ | $1.1 \pm 0.8^{c,*}$ | $0.0 \pm 0^{d}$ |

Different letters show statistical significance at intragroup comparisons, $p < 0.05$, repeated ANOVA.
VAS, visual analog scale.
* The differences immediately, and 1, 3, and 7 days after treatment were statistically significant between the laser group and the control group; $p < 0.05$, paired *t*-test.

**Table 2**
Mean degree of HRAS scores and standard deviation in both groups over 10 days.

| | Baseline | Day 1 | Day 3 | Day 7 | Day 10 |
|---|---|---|---|---|---|
| Laser | $4 \pm 0^{a}$ | $3.1 \pm 0.4^{b,*}$ | $1.2 \pm 1.4^{c,*}$ | $1 \pm 0^{d,*}$ | $1 \pm 0^{d}$ |
| Placebo | $4 \pm 0^{a}$ | $4 \pm 0^{a,*}$ | $3.2 \pm 1.6^{b,*}$ | $1.6 \pm 1.2^{c,*}$ | $1 \pm 0^{d}$ |

Different letters show statistical significance at intragroup comparisons, $p < 0.05$, repeated ANOVA.
HRAS, healing of recurrent aphthous stomatitis.
* The differences at 1, 3 and 7 days after treatment were statistically significant between the laser group and the control group, $p < 0.05$, paired *t*-test.

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## OVERALL SUMMARY

Although there is no agreement in the literature for the treatment of RAS, the goal is to manage a patient's symptoms experiencing pain from RAS. Traditional treatment for RAS includes topical and systemic steroids and/or antimicrobial therapy. While they appear to be useful in managing discomfort associated with RAS, topical +/- systemic steroids and/or antimicrobials may cause unwanted side effects due to their ability to enter the patient's systemic circulation. In this study, a Er,Cr:YSGG laser was used to treat patients with RAS and showed promising findings when compared to non-irradiated lesions. Using a visual analog scale for pain and healing score for RAS lesions treated in this study, significant differences in pain and healing were elicited at days 1, 3, and 10.

## CLINICAL SIGNIFICANCE AND IMPACT

Several studies have been conducted using different laser therapies for the treatment of RAS. Non-thermal CO2 lasers have been used in the 1w power at de-focused continuous mode to effectively decrease pain levels of RAS lesions when compared to placebo (Zand et. al, 2012). High power CO2 lasers at an output of 4w power with similar findings (Colvard, 1991). Albrektson and colleagues used low-level laser therapy to treat RAS lesions with patients reporting a reduction in discomfort while eating, drinking, and brushing teeth (Albrektson et. al, 2014). In the present study, a Er,Cr:YSGG laser was used with the added benefit of minimizing tissue distortion due to less thermal deep or lateral damage when compared to infrared and Nd:YAG lasers. The authors propose the coagulation effect of the irradiated lesions may cause reduced sensitivity to external stimuli. They also propose a bactericidal effect on the treated lesions, for which it is known that certain microbes can create a hyperalgesic effect on oral lesions like RAS. Further studies may further validate the use of Er,Cr:YSGG laser as a safe, effective, and pain-free modality to treat RAS in the dental setting. ■

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# A CLINICAL LOOK

## *Low Level Laser Therapy, Er,Cr:YSGG Laser and Fluoride Varnish for Treatment of Dentin Hypersensitivity After Periodontal Surgery: A Randomized Clinical Trial*

Amir Moeintaghavi1 & Farzaneh Ahrari1 & Nahid Nasrabadi1 & Amir Fallahrastegar1 & Javad Sarabadani2 & Fatemeh Rajabian3

Lasers in Medical Science, https://doi.org/10.1007/s10103-021-03310-4

## METHODS AND MATERIALS

This randomized, double-blinded clinical trial investigated the use of low-level laser therapy (LLLT), erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser, and fluoride varnish on dentin hypersensitivity (DH) after periodontal surgery. Twenty-four patients and 60 jaw quadrants were recruited. Inclusion criteria were patients who had undergone periodontal surgery in at least 2 quadrants of the upper/lower jaw due to increased pocket depths (>5mm). Exclusion criteria involved carious lesions, crown fractures, defective restorations, teeth with pulpitis, pregnant + feeding women, use of analgesic/anti-inflammatory drugs 72 hours prior to commencement of the study, professional desensitizing treatment within 6 months prior, or use of desensitizing toothpaste within 3 months.

Treatment groups were divided into 4 groups: (1) Low-level laser therapy [LLLT] with indium-gallium-aluminum-phosphide [InGaAlP] and gallium-aluminum-arsenide [GaAlAS] diode lasers (2) Erbium, chromium:yttrium-scandium-gallium-garnet (Er,Cr:YSGG) laser (3) Fluoride varnish (4) Placebo laser [same protocol as group 1 with laser turned off]. Laser treatment was performed at one visit for each test subject with one operator. Oral hygiene instruction was rendered, and each subject was told not to use desensitizing nor fluoride agents. Post-op sensitivity was assessed at 3 intervals for sensitivity to a cold spray [immediately after removal of the periodontal pack placed at the time of surgery and before treatment from either of the 4 aforementioned groups (T0), immediately after treatment (T1) and 1-week post-op (T2)]. A visual analog scale (VAS) was used with 0 indicating no pain and 10 the worst possible pain.

**Table 1** The mean and standard deviation (SD) of visual analog scale (VAS) scores in the study group at different assessment intervals

| Group | Baseline (T0) | Immediate (T1) | One week (T2) | Statistical analysis* |
|---|---|---|---|---|
| | Mean ± SD | Mean ± SD | Mean ± SD | |
| Low level laser therapy | 6.43 ± 1.90[a] | 4.93 ± 2.31[b] | 5.33 ± 2.40 [b, B,C] | $P = 0.031$ |
| Er,Cr:YSGG laser | 7.83 ± 1.59[a] | 5.47 ± 1.25 [b] | 3.50 ± 1.38 [c, A] | $P < 0.001$ |
| Fluoride varnish | 7.20 ± 1.84 [a] | 5.40 ± 2.25 [b] | 5.10 ± 1.99 [b, A, B] | $P < 0.001$ |
| Placebo laser | 7.07 ± 1.74 | 6.30 ± 2.16 | 7.10 ± 1.44 [C] | $P = 0.069$ |
| Statistical analysis* | $P = 0.205$ | $P = 0.331$ | $P < 0.001$ | |

## RESULTS

**Table 1:** Severity of pain decreased from T0 to T1 in all groups. VAS scores in the fluoride varnish and Er,Cr:YSGG laser groups continued to reduce over time. LLLT and placebo groups experienced increases in pain over time. LLLT and fluoride varnish groups showed statistically significant reductions in dentin hypersensitivity from baseline to T2, with the Er,Cr:YSGG group experiencing significant decreases among all assessment intervals (highlighted in yellow). One-way analysis of variance (ANOVA) showed no significant difference in the severity of pain between the four groups at T0 and T1. Mean VAS scores in the Er,Cr:YSGG laser group at T2 was significantly lower than LLLT and placebo groups. The fluoride varnish group experienced significantly lower DH when compared to the placebo group. Figure 1 below shows a line chart representing VAS scores of the study groups at different assessment intervals:

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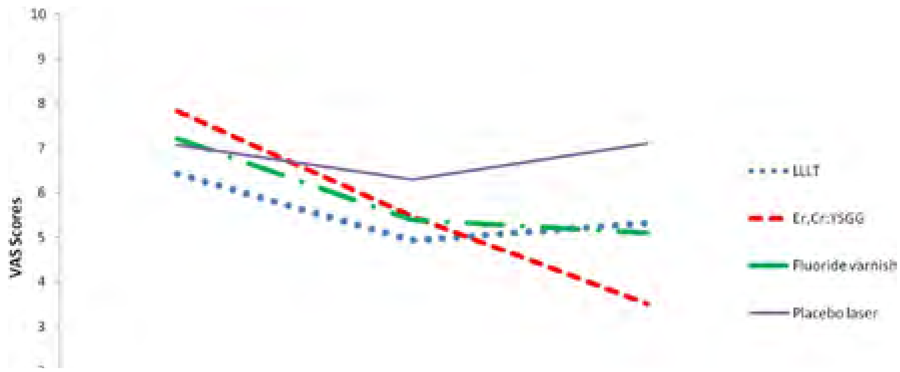


**Fig 1** A line chart representing VAS scores of the study groups at different assessment intervals. Significant differences were found between T0–T1 and T0–T2 for the LLLT and fluoride varnish groups and between T0–T1, T1–T2 and T0–T2 for the Er,Cr:YSGG laser group

## OVERALL SUMMARY

The three experimental modalities used in this study were effective in reducing pain immediately and 1 week after treatment compared to baseline (T0). At 1 week post-op (T2), the Er,Cr:YSGG laser group and fluoride varnish group demonstrated significantly lower VAS scores compared to placebo. The Er,Cr:YSGG laser group experienced a 30% reduction in pain immediately after treatment and 55% reduction at 1 week after irradiation. For immediately after treatment and at 1-week post-application of fluoride varnish, the fluoride varnish group experienced a 25% and 29% reduction in pain, respectively. Although the difference from immediate to 1 week is not as pronounced as the Er,Cr:YSGG laser group, fluoride varnish appears to be a practical and effective modality in the treatment of dentin hypersensitivity.

## CLINICAL SIGNIFICANCE AND IMPACT

The outcomes of this study are in agreement with other studies that elicited superior results in the treatment of dentin hypersensitivity using a Er,Cr:YSGG laser. Although some studies may contradict the findings of the present study, differences in outcomes may be related to differences in laser parameters and radiation protocols as well as differences in study designs. Limitations of this study were small sample size and short follow-up period. Overall, it was shown that Er,Cr:YSGG lasers and fluoride varnish are effective at treating dentin hypersensitivity and can be recommended for rapid DH reduction in patients who undergo periodontal surgery. ■

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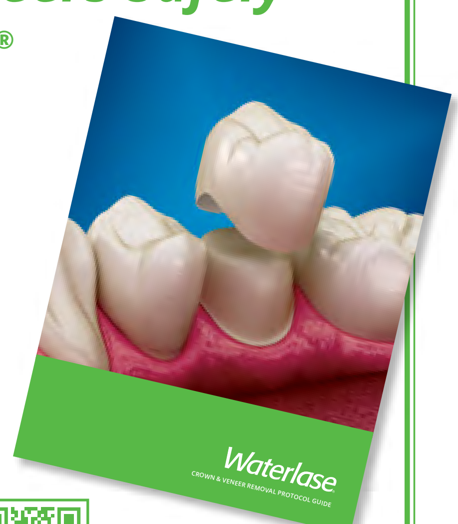

# A CLINICAL LOOK

## Periodontal Decontamination Using the Diode Laser

### *Effect of Hydrogen Peroxide Photoactivated Decontamination Using 940 nm Diode Laser in Periodontal Treatment: A Pilot Study*

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## INTRODUCTION

Periodontal disease represents an important concern of public health worldwide and is probably the most common chronic infectious disease among human kind.[1] In chronic periodontal disease, the subgingival biofilm is responsible for hard and soft tissue loss. According to Socransky complexes, the most important pathogens in adult periodontal disease are represented by the red complex, which includes Porphyromonas gingivalis, Treponema denticola, and Tannerella forsythia. The orange complex bacteria are usually found together with the red complex and acts like a bridge between the primary and the secondary colonizers of the subgingival biofilm.

Beside Aggregatibacter actinomycetemcomitans, some species from red and orange complexes have the ability to invade the gingival epithelial and endothelial cells.[2–4] This virulence capability of the pathogenic bacteria may lead to reduced outcome of the scaling and root planning (SRP) technique when used as a sole therapy. Researchers suggested the use of antibiotics in conjunction with SRP but because of the high frequency of increase in antibiotic resistance, many periodontal pathogens cannot be removed from the periodontal structures. Furthermore, SRP fails to eliminate pathogenic bacteria in periodontal inaccessible areas such as deep periodontal pockets, root concavities, furcation involvement, and so on. To overcome these inconveniences, researchers proposed the use of lasers in periodontal therapy.[5]

The use of lasers as a complementary procedure to conventional therapy may facilitate treatment outcomes with improved periodontal regeneration potential. From the near-infrared spectrum lasers, the Nd:YAG laser can remove periodontal pathogens because of its thermal effect. However, changes in the neighboring tissues can be attributed to these unwanted thermal effects. The diode lasers that belong to the 655–980 nm spectrum could represent a safer alternative.6 Because of the transmission or scattering effect on hydroxyapatite, diode lasers have no effect on calculus. Anaerobic bacterial species such as P. gingivalis and Prevotella intermedia produce black pigments in Brucella media from blood agar. Hemoglobin in the soft periodontal tissues behaves like a chromophore, being absorbed by the diode laser. It acts as an endogenous dye, which can increase the laser effect at this level.[7] Therefore, the laser can be used as an adjuvant to SRP owing to its bactericidal and detoxifying effects. Dukic et al. have shown that clinical parameters in moderate periodontal pockets ranging from 4 to 6 mm depth can be improved by repeating the application of 980 nm laser in combination with conventional treatment.[8]

Other laser-assisted periodontal procedures use photosensitizers like dyes or different substances activated by different laser wavelengths to eliminate periodontal bacteria. Antimicrobial photodynamic therapy (aPDT) uses dyes like toluidine blue, methylene blue, rose Bengal, and indocyanine green photoactivated by laser wavelengths ranging from 630 to 810 nm.[9–11] These dyes, in the presence of light, produce reactive oxygen species (ROS) capable of damaging the biomolecules and cause oxidation of cellular structures leading to selective microorganism death.[12] Other photoactivated procedures use the photolysis of hydrogen peroxide ($H_2O_2$) with 405 nm wavelength.[13]

When consulting the literature, the ability of 940 nm laser wavelength to eliminate periodontal bacteria is lacking support. A more recent study investigated the use of $H_2O_2$ photoactivation with 940 nm diode laser without the use of the SRP.[14]

Based on these initial findings, we hypothesized that the photoactivation of $H_2O_2$ with 940 nm diode laser in the presence of conventional SRP will improve the periodontal condition more than SRP alone and in combination with 940 nm diode laser. Therefore, the aim of this study was to evaluate the bactericidal effect and the clinical outcomes of the photoactivation of $H_2O_2$ with 940 nm diode laser in combination with SRP in the nonsurgical periodontal treatment.

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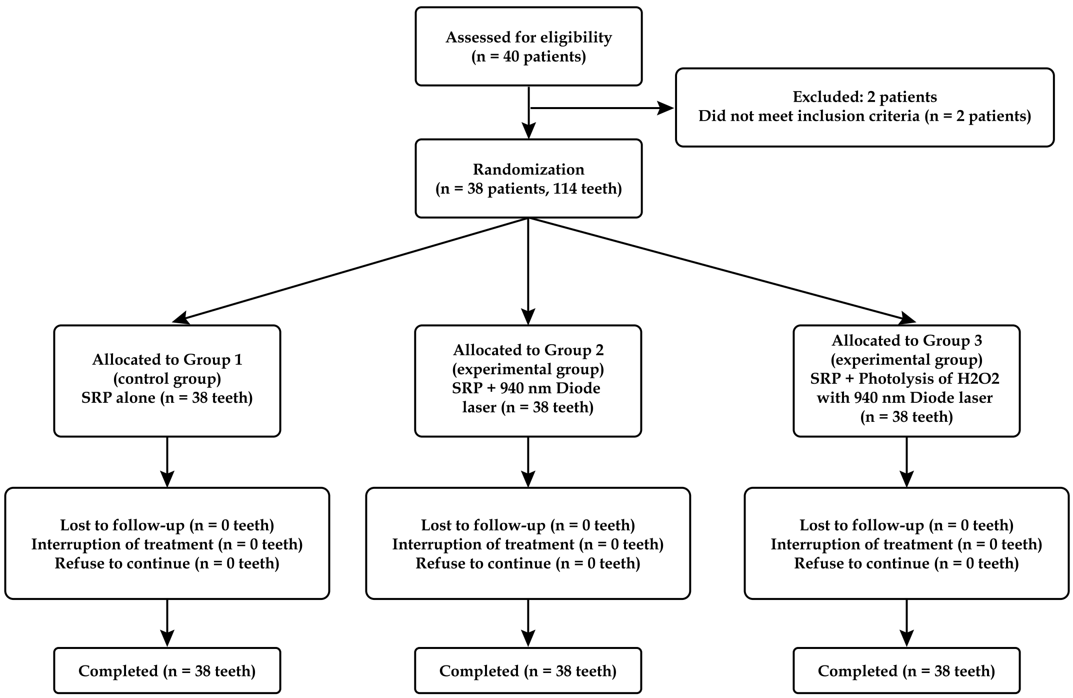
Fig. 1




## METHODS AND MATERIALS

This study was designed as a randomized controlled, single-blind, multicenter trial with a split-mouth design to compare the antimicrobial effect of nonsurgical periodontal therapy with SRP alone, 940 nm diode laser in combination with SRP, and photoactivation of $H_2O_2$ with 940 nm diode in combination with SRP. The study protocol was approved by the Ethical Committee of Ovidius University of Constanta Faculty of Dental Medicine, with No. 14533/ 22.09.2015 and conducted according to the Declaration of Helsinki (revised in 2013, Fortaleza, Brazil).

For this study, 40 patients with moderate to severe periodontal disease were selected from the Periodontology Department of Ovidius University of Constanta—Faculty of Dentistry (Constanta, Romania) and a private dental clinic (Dental Laser Center, Constanta, Romania). All subjects signed a written informed consent document before treatment. The inclusion criteria were as follows: at least 16 natural teeth present in the oral cavity distributed in 4 quadrants, a minimum 5 mm periodontal probing depth (PPD) per quadrant with bone resorption evidenced both clinically and radiologically and bleeding on probing (BoP) in all 4 quadrants. The exclusion criteria were as follows: patients who are during active periodontal treatment or have had undergone periodontal treatment within 12 months, patients who have had antibiotic therapy (systemic or local) over the past 6 months, smokers, systemic conditions that may affect the therapeutic outcome (diabetes type 1 and 2, immune deficiency, hepatitis B virus, hepatitis C virus, cancer, hematological disorders, epilepsy, etc.), pregnancy, breastfeeding, incapacity, or refusal to follow the study protocol, and severe comorbid conditions that may affect life expectancy within 1 year (e.g., metastatic cancer). Two patients did not meet the inclusion criteria and were excluded: one exclusion was because of previous periodontal treatment and another was owing to antibiotic administration within the last 6 months for periodontal abscess. A total of 38 patients participated in the study until the end. The flow chart of the study is given in Fig. 1.

**Table 1. Sample Patients**

| | *All groups* |
|---|---|
| *N* | 38 |
| Age, years, mean ±SD | 47.45 ± 7.82 |
| Gender, M/F, *n* (%) | 21/17 (55.3/44.7) |
| PPD, mm, mean ± SD | 3.85 ± 0.74 |
| CAL, mm, mean ± SD | 5.41 ± 1.04 |
| BoP, %, mean ± SD | 58.08 ± 24.06 |
| Stage of periodontitis moderate/severe, *n*(%) | 13/25 (34.2/65.8) |

BoP, bleeding on probing; CAL, clincal attachment level; PPD, periodontal probing depth; SD, standard deviation


**Fig. 2**
Group 1 (SRP) was performed using ultrasonic scaler (a) and manual Gracey curette (b). SRP, scaling and root planning.

Baseline examination was performed 1 week before periodontal treatment and included clinical and radiological analysis. The following clinical periodontal parameters were recorded: PPD, clinical attachment level (CAL), and BoP. Probing was performed using a manual periodontal probe (CP15; Hu-Friedy, Inc., Leimen, Germany) at six sites per tooth by an experienced periodontist in both facilities. Based on the initial findings, three test teeth (one in each quadrant) that exhibited ‡5 mm PPD and (+) BoP were selected from each patient, resulting in a total of 114 test teeth. The deepest PPD from each test tooth was selected as the test site. Teeth with fixed prosthesis (single crowns or bridges), furcation involvement, second and third molars were excluded.

The test sites were randomly allocated using Microsoft Excel (Microsoft Corporation, WA). The diagnosis for the subjects and the sample of patients are given in Table 1.

Based on the method of randomization, each patient quadrant was allocated to one of the three treatment groups as follows: Group 1: SRP as monotherapy; Group 2: SRP and 940 nm diode laser decontamination; and Group 3: SRP $+H_2O_2$ photoactivation with 940 nm diode laser. Thus, the test sites in a patient were treated with different treatment procedures to compare their effects within the same individual (i.e., split-mouth study). The remaining quadrant was treated with SRP and it was not microbiologically assessed.

### TREATMENT PROTOCOL

One week after the baseline periodontal examination and microbiological sampling, professional dental cleaning was performed using conventional ultrasonic scaler consisting of supragingival calculus removal, polishing of the teeth surfaces with rotary brushes and prophylactic paste and Airflow (PROPHYflex 3; Kavo, Biberach, Germany). Every patient received oral hygiene instructions that included modified BASS brushing technique and mouth rinse without alcohol and chlorhexidine gluconate, twice a day after tooth brushing. A week later, nonsurgical periodontal treatment was performed under local anesthesia by another experienced periodontist who was not designated as examiner. The periodontal treatment was represented by a half-mouth protocol and divided into two sessions, with 1 day of resting between them:

> **First session**: upper and lower right; **Second session**: upper and lower left. In each quadrant, the selected teeth and the adjacent mesial and distal surfaces of the neighboring teeth were treated with one of the three nonsurgical periodontal therapies, whereas the remaining teeth were treated using the conventional periodontal treatment with manual Gracey curettes (Hu-Friedy, Inc.) and ultrasonic scaler (Piezolux; Kavo).

In the control group (Group 1), SRP was performed using manual Gracey curettes and ultrasonic scaler until the operator judged sufficient (Fig. 2a, b). In Group 2, SRP was performed in the same manner as in Group 1, followed by decontamination with diode 940 nm laser (Epic 10; Biolase) with 7 mm length and 300 lm in diameter uninitiated fiber tip (Fig. 3a), 1.1 W, continuous wave (CW). The activated fiber was applied from the bottom to the free gingival margin of the periodontal pocket in parallel with the root surface and side-to-side movements were performed for *30 sec per test surface (Fig. 3b). Group 3 received the SRP procedure followed by photoactivation of 3% $H_2O_2$ with 940 nm diode laser with 300 lm uninitiated fiber tip, 1.1 W, CW, exposure time for *30 sec per test surface (Fig. 4). The 3% $H_2O_2$ solution was inserted to the bottom of the periodontal pocket using a disposable plastic needle similar to the endodontic irrigation (Fig. 4a) and photoactivated by 940 nm laser, which was applied in the same manner as in Group 2 (Fig. 4b, c). Thus the combination of 3% $H_2O_2$ and laser light generated hydroxyl radicals as a result of photoactivation (Fig. 4d). The laser parameters for Groups 2 and 3 are summarized in Table 2.

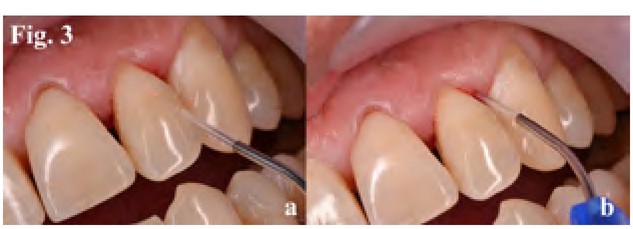


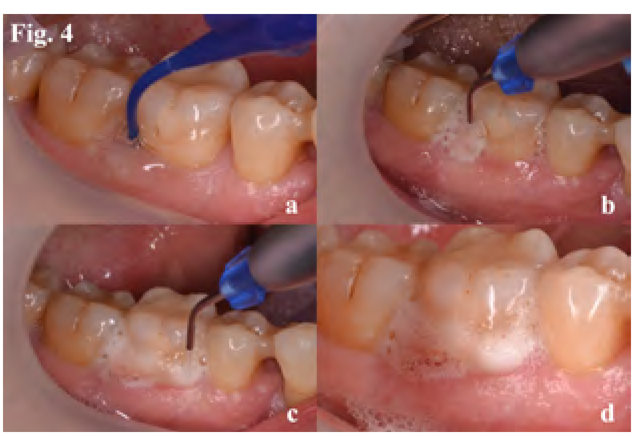

**Fig. 3**
Group 2 (SRP +940 nm diode laser)—uninitiated tip (a) for decontamination only (b).

**Table 2. The Parameters of the Light Used for Laser-Assisted Periodontal Treatment (Groups 2 and 3)**

| | |
|---|---|
| *Device* | |
| Name, manufacturer | Epic X, BIOLASE |
| Power output | 10 W |
| Wavelength of light source | 940 ± 10nm |
| Type of laser | Diode laser light |
| Power mode | CW |
| Shape, size, length of the fiber tip | Flat tip of 300 $\mu$m in diameter, 7 mm in length |
| *Treatment* | |
| Power | 1.1 W |
| Exposure time | 30 sec |
| Frequency of treatment | Once |
| Beam area | 0.00071 cm$^2$ |
| Power density | 1549 W/cm$^2$ |
| Engergy density | 33 J/cm$^2$ |

CW, continuous wave.

Microbiological assessment was performed 1 week before periodontal treatment. Microbiological samples were obtained from the selected periodontal pockets in each quadrant at baseline (before treatment) and at 1 month after the periodontal treatment by the blinded examiner. The sampling sites were isolated and dried while the supragingival plaque was removed. Sterile paper points were inserted to the bottom of the test sites and held in place for 30 sec, then removed by avoiding contact with saliva or epithelium of the oral cavity and placed into transfer tubes (individual sampling) provided by Pet Deluxe Diagnostic Set (MIP Pharma GmbH, Blieskastel-Niederwu¨rzbach, Germany). One sterile paper point was used per site (38 patients, 3 tested teeth, 1 paper point/site/quadrant = 114 individual samplings). All three transfer tubes were transported in the same box. The microbiological assays were performed by means of real-time polymerase chain reaction (PCR) by the MIP Pharma Laboratory, to determine qualitatively and quantitatively nine periodontal pathogens: A. actinomycetemcomitans, P. gingivalis, T. forsythia, Treponema denticola, Fusobacterium nucleatum, P. intermedia, Peptostreptococcus micros, Eubacterium nodatum, Capnocytophaga gingivalis. In addition, the total bacteria count (TBC) was assessed per sample. The company stated that the detection limit for each bacterium was confirmed at 100 germs per milliliter.




### FOLLOW-UP EXAMINATION

Clinical periodontal parameters PPD, BoP, and CAL were first assessed 3 months after the periodontal treatment by the same blinded examiner. Only the test teeth were assessed. To eliminate any possible bias, intra-examiner calibration was performed both initially and at 3 months after examination. Three repeated measurements were performed and had to show a >90% agreement for –1 mm between initial and repeated probes. The quantitative and qualitative of TBC and the nine periodontal pathogenic bacteria were recorded after 1 month.

### STATISTICAL ANALYSIS

The experimental data were performed using the statistical processing program SPSS Statistics 23 (IBM Corp., Armonk, NY). The following tests were used: descriptive statistics (for characterization of discrete and continuous variables defined at the database level), charts, nonparametric statistical tests (the $\chi 2$ test of the association between two class variables, McNemar test for significance change, Mann–Whitney test used for testing the difference between two independent groups and the Wilcoxon test was used to test the difference between two pair groups) and $p < 0.05$ was considered significant. The periodontal treatment protocol of the control and experimental groups are given in Table 3.

## RESULTS

The postoperative healing was uneventful in all cases and no complications such as periodontal abscesses or infections were observed throughout the study. During the study, no antibiotic therapy or other medication were administrated for all participating subjects. Table 4 provides the clinical characteristics of each quadrant assigned for the control and experimental groups. From the total number of teeth investigated in this study, 80 teeth were single rooted and 34 multirooted.

**Fig. 4**
Group 3 (SRP+photoactivation of 3% $H_2O_2$ using 940 nm diode laser)—insertion of $H_2O_2$ to the bottom of periodontal pocket (a) and activation with uninitiated tip (b, c). Generation of hydroxyl radicals (d). $H_2O_2$, hydrogen peroxide.

**Table 3. Study Protocol for Control and Test Groups**

| | *Control* | *Test* | |
|---|---|---|---|
| *Groups* | *Group 1* | *Group 2* | *Group 3* |
| Baseline | Initial consult<br>Diagnosis<br>Informed consent | Initial consult<br>Diagnosis<br>Informed consent | Initial consult<br>Diagnosis<br>Informed consent |
| Week 1 | Periodontal indices recording (PPD, CAL BoP)<br>Microbiology sampling | Periodontal indices recording (PPD, CAL BoP)<br>Microbiology sampling | Periodontal indices recording (PPD, CAL BoP)<br>Microbiology sampling |
| Week 2 | Professional dental cleaning<br>OHI | Professional dental cleaning<br>OHI | Professional dental cleaning<br>OHI |
| Week 3 | SRP | SRP + 940 nm diode laser, 1.1 W, CW | SRP + $H_2O_2$ + 940 nm diode laser, 1.1 W, CW |
| 1 Month | Microbiology sampling | Microbiology sampling | Microbiology sampling |
| 3 Month | Periodontal indices recording (PPD, CAL, BoP) | Periodontal indices recording (PPD, CAL, BoP) | Periodontal indices recording (PPD, CAL, BoP) |

H2O2, hydrogen peroxide; OHI, oral hygiene instructions; SRP, scaling and root planning.

Since the data distribution was nonparametric and considering the periodontal microbiota analysis in the literature, the median and percentiles are of relevance to analyze the variables. The microbiological variables at baseline and at 1 month postoperative are given in Table 5.

All nine bacterial species evaluated in this pilot study were detected in different levels before the treatment. Microbiological analysis showed a decrease in TBC postoperative in all investigated groups.

The red virulence complex represented by P. gingivalis, T. denticola, and T. forsythia recorded highly significant results ( $p = 0.000$) in all three investigated groups. Regarding the orange virulence complex, the postoperative results showed significantly reduced values ( $p < 0.05$), but with some particularities. Pathogen P. intermedia in Group 1 recorded a p-value = 0.03, $p = 0.008$ in Group 2, and $p = 0.000$ in Group 3. P. micros showed values for Group 1 with $p = 0.04$, for Group 2 $p = 0.029$, and for Group 3 $p = 0.000$.

F. nucleatum failed to show a significant reduction in Group 1 ( $p = 0.220$) and Group 2 ( $p = 0.872$), in contrast to Group 3 results ( $p = 0.000$).

**Table 4. Clinical Characteristics of Each Quadrants**

| *Tested groups assigned to quadrants* | *Nuber of teeth in each quadrant (median)* | *Number of teeth that exhibited PD ≥5mm/quadrant (median)* | *Single/ multirooted teeth investigated* |
|---|---|---|---|
| Group 1 | 6 | 4 | 27/11 |
| Group 2 | 7 | 5 | 25/13 |
| Group 3 | 7 | 5 | 28/10 |

The associated orange complex, represented by E. nodatum, registered a significant reduction in all three investigated groups ( $p = 0.000$).

The green complex, being a health-compatible complex, expressed different values for C. gingivalis. In Group 1, significant differences ( $p = 0.031$) were observed, unlike the groups treated with laser (Group 2, $p = 0.275$; Group 3, $p = 0.858$).

To have a complete image of all the processed variables, we also considered performing the qualitative assessment of the bacteria distribution in all tested groups. Table 6 provides the qualitative analysis of the microbial species assessed by means of independent median sample and percentiles.

A. actinomycetemcomitans showed a low frequency among the tested groups. Regarding the bacteria count, A. actinomycetemcomitans was recorded after the Group 1 (SRP) treatment and before Group 3 (SRP +$H_2O_2$+diode laser), whereas Group 2 (SRP+diode laser 940 nm) could not be detected (Table 6).

From a qualitative point of view, Groups 1 and 2 failed to show significant postoperative outcomes ( $p > 0.05$) for orange complex (P. intermedia, P. micros, F. nucleatum), in contrast to Group 3 which showed significant reduction ( $p < 0.001$) for P. gingivalis, T. denticola, T. forsythia, P. intermedia, P. micros, F. nucleatum, and E. nodatum.

For periodontal index examination at baseline and postoperative, the result of intra-examiner reproducibility of >90% for –1 mm between initial and repeated probes was 100%. Tables 7 and 8 show the outcome of the clinical periodontal indices represented by the PPD, CAL, and BoP.

All the tested groups showed a significant postoperative reduction ( $p = 0.000$). To have a better understanding with

**Table 5. Independent Sample Test of Median and Percentiles for Microbiological Variables**

| | Group 1 (SRP) | | | Group 2 (SRP+diode 940 nm) | | | Group 3 (SRP +H2O2+Diode 940 nm) | | |
|---|---|---|---|---|---|---|---|---|---|
| *Variables* | *Median* | *25%-75%* | *P* | *Median* | *25%-75%* | *P* | *Median* | *25%-75%* | *P* |
| TBC | | | | | | | | | |
| Baseline | 13.5 x $10^6$ | 6.5 x $10^6$–28 x $10^6$ | 0.124 | 7.15 x $10^6$ | 2.95 x $10^6$–29.25 x $10^6$ | 0.001 | 18.5 x $10^6$ | 3.625 x $10^6$–58 x $10^6$ | 0.000 |
| 1 Month postop | 5.85 x $10^6$ | 1.275 x $10^6$–17.25 x $10^6$ | | 3.15 x $10^6$ | 1.475 x $10^6$–12 x $10^6$ | | 0.71 x $10^6$ | 0.09525 x $10^6$–3.525 x $10^6$ | |
| *Aggregatibacter actinomycetemcomitans* | | | | | | | | | |
| Baseline | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | – | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | – | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | – |
| 1 Month postop | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | | 0x $10^6$ | 0x $10^6$–0 x $10^6$ | |
| *Porphyromonas gingivalis* | | | | | | | | | |
| Baseline | 0.082 x $10^6$ | 0.009875 x $10^6$–0.57 x $10^6$ | 0.000 | 0.125 x $10^6$ | 0.0265 x $10^6$–0.36 x $10^6$ | 0.000 | 0.155 x $10^6$ | 0.0455 x $10^6$–0.5125 x $10^6$ | 0.000 |
| 1 Month postop | 0x $10^6$ | 0 x $10^6$–0.00595 x $10^6$ | | 0.00023 x $10^6$ | 0x $10^6$–0.023 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Treponema denticola* | | | | | | | | | |
| Baseline | 0.051 x $10^6$ | 0.031 x $10^6$–0.1625 x $10^6$ | 0.000 | 0.0565 x $10^6$ | 0.022 x $10^6$–0.21 x $10^6$ | 0.000 | 0.102 x $10^6$ | 0.033 x $10^6$–0.285 x $10^6$ | 0.000 |
| 1 Month postop | 0 x $10^6$ | 0 x $10^6$–0.00885 x $10^6$ | | 0.0005 x $10^6$ | 0 x $10^6$–0.007075 | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Tannerella forsythia* | | | | | | | | | |
| Baseline | 0.033 x $10^6$ | 0.0066 x $10^6$–0.155 x $10^6$ | 0.000 | 0.039 x $10^6$ | 0.009375 x $10^6$–0.13 x $10^6$ | 0.000 | 0.0395 x $10^6$ | 0.016 x $10^6$–0.2025 x $10^6$ | 0.000 |
| 1 Month postop | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0.002575 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| Prevotella intermedia | | | | | | | | | |
| Baseline | 0.024 x $10^6$ | 0 x $10^6$–0.1175 x $10^6$ | 0.030 | 0.00775 x $10^6$ | 0.000357 x $10^6$–0.17 x $10^6$ | 0.008 | 0.057 x $10^6$ | 0 x $10^6$–0.245 x $10^6$ | 0.000 |
| 1 Month postop | 0.00012 x $10^6$ | 0 x $10^6$–0.01125 x $10^6$ | | 0.056 x $10^6$ | 0 x $10^6$–0.02975 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Peptostreptococcus micros* | | | | | | | | | |
| Baseline | 0.0135 x $10^6$ | 0.00315 x $10^6$–03325 x $10^6$ | 0.040 | 0.006050 x $10^6$ | 0.0016 x $10^6$–0.0185 x $10^6$ | 0.029 | 0.00915 x $10^6$ | 0.002775 x $10^6$–0.0335 x $10^6$ | 0.000 |
| 1 Month postop | 0.0053 x $10^6$ | 0.0004325 x $10^6$–0.014 x $10^6$ | | 0.00425 x $10^6$ | 0.0004875 x $10^6$–0.0098 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Fusobacterium nucleatum* | | | | | | | | | |
| Baseline | 0 x $10^6$ | 0 x $10^6$–0.01875 x $10^6$ | 0.220 | 0 x $10^6$ | 0 x $10^6$–0.00595 x $10^6$ | 0.872 | 0 x $10^6$ | 0 x $10^6$–0.00885 x $10^6$ | 0.000 |
| 1 Month postop | 0.000065 x $10^6$ | 0 x $10^6$–0.007225 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0.003625 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Eubacterium nodatum* | | | | | | | | | |
| Baseline | 0.00017 x $10^6$ | 0 x $10^6$ –0.00155 x $10^6$ | 0.000 | 0 x $10^6$ | 0 x $10^6$–0.0006825 x $10^6$ | 0.000 | 0 x $10^6$ | 0 x $10^6$–0.00165 x $10^6$ | 0.000 |
| 1 Month postop | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | | 0 x $10^6$ | 0 x $10^6$–0 x $10^6$ | |
| *Capnocytophaga gingivalis* | | | | | | | | | |
| Baseline | 0.000505 x $10^6$ | 0 x $10^6$–0.00485 x $10^6$ | 0.031 | 0.0015 x $10^6$ | 0 x $10^6$–0.009875 x $10^6$ | | 0.00115 x $10^6$ | 0 x $10^6$–0.006675 x $10^6$ | 0.858 |
| 1 Month postop | 0.00555 x $10^6$ | 0.000335 x $10^6$–0.02525 x $10^6$ | | 0.0028 x $10^6$ | 0.0001575 x $10^6$–0.02425 x $10^6$ | 0.275 | 0.0015 x $10^6$ | 0 x $10^6$–0.006025 x $10^6$ | |

postop, postoperative; TBC, total bacteria count.

**Table 6. Qualatative Analysis for Microbiological Variables**

| | Group 1 (SRP) | | Group 2 (SRP + 940 nm) | | Group 3 (SRP +H2O2+940 nm) | |
|---|---|---|---|---|---|---|
| *Variables* | *Bacteria count, n (%)* | *p* | *Bacteria count, n (%)* | *p* | *Bacteria count, n (%)* | *p* |
| TBC | | | | | | |
| Baseline | 38 (100) | – | 38 (100) | – | 38 (100) | – |
| 1 Month postop | 38 (100) | | 38 (100) | | 38 (100) | |
| *A. actinomycetemcomitans* | | | | | | |
| Baseline | 0 (0) | – | 0 (0) | – | 1 (2.7) | – |
| 1 Month postop | 1 (2.7) | | 0 (0) | | 0 (0) | |
| *P. gingivalis* | | | | | | |
| Baseline | 35 (92.1) | <0.001 | 35 (92.1) | <0.001 | 33 (86.8) | <0.001 |
| 1 Month postop | 17 (44.7) | | 20 (52.6) | | 5 (13.2) | |
| *T. denticola* | | | | | | |
| Baseline | 35 (92.1) | <0.001 | 36 (94.7) | <0.001 | 36 (94.7) | <0.001 |
| 1 Month postop | 18 (47.4) | | 20 (52.6) | | 3 (7.9) | |
| *T. forsythia* | | | | | | |
| Baseline | 37 (97.4) | <0.001 | 38 (100) | <0.001 | 37 (97.4) | <0.001 |
| 1 Month postop | 8 (21.1) | | 15 (39.5) | | 0 (0) | |
| *P. intermedia* | | | | | | |
| Baseline | 27 (71.1) | 0.118 | 30 (78.9) | 0.727 | 28 (73.7) | <0.001 |
| 1 Month postop | 20 (52.6) | | 28 (73.7) | | 6 (15.8) | |
| *P. micros* | | | | | | |
| Baseline | 36 (94.7) | 0.125 | 36 (94.7) | 0.065 | 38 (100) | <0.001 |
| 1 Month postop | 31 (81.6) | | 29 (76.3) | | 7 (18.4) | |
| *F. nucleatum* | | | | | | |
| Baseline | 17 (44.7) | 0.815 | 12 (31.6) | 0.549 | 17 (44.7) | <0.001 |
| 1 Month postop | 19 (50) | | 15 (39.5) | | 5 (13.2) | |
| *E. nodatum* | | | | | | |
| Baseline | 22 (57.9) | <0.001 | 18 (47.4) | <0.001 | 16 (42.1) | <0.001 |
| 1 Month postop | 1 (2.6) | | 3 (7.9) | | 38 (100) | |
| *C. gingivalis* | | | | | | |
| Baseline | 25 (65.8) | 0.057 | 28 (73.7) | >0.1 | 24 (63.1) | >0.1 |
| 1 Month postop | 33 (86.8) | | 29 (76.3) | | 25 (65.7) | |

regard to our proposed therapy, we decided to compare the outcome of the test group with the experimental groups and the experimental groups between them. As Table 9 shows, Group 3 exhibited a statistically highly significant outcome in contrast to Groups 1 and 2.

## DISCUSSIONS

To date, there was no report that evaluated the bactericidal effect of 3% $H_2O_2$ photoactivation with 940 nm diode laser in conjunction with SRP procedure in trea.g periodontal disease.

Since it is an in vivo pilot study, the rational of performing the microbial sampling at 1 month after therapy was to eliminate any potential risk that could influence the bactericidal outcomes related to speed and degree of further biofilm recolonization.[15] Thus, for the periodontal examination a minimum of 3 months was necessary to assess the first relevant clinical signs of periodontal status.

This study is the first report regarding the possible antimicrobial effect of the $H_2O_2$ photoactivation with 940 nm diode laser. Although this wavelength is lacking support when it comes to bactericidal effect in the treatment of periodontal pockets, in this study we showed that in combination with SRP a strong bactericidal effect can be achieved. Nevertheless, there is no report about photoactivation of any solutions with this wavelength to increase their antimicrobial effect against periodontal microorganisms.

However, some limitation should be noted. The first limitation of this study was based on the small sample size of only 38 patients. However, a pilot study was necessary to investigate the bactericidal effect of H2O2 photoactivation with 940 nm diode laser. Second limitation was with regard to 1-month microbiological examination after periodontal treatments. Because of the high cost of real-time PCR analysis of three individual samples per patient, we decide not to increase the medical costs for further investigation such as 3 and 6 months. The third limitation was represented by the short-term clinical outcomes of only 3 months, which may lead to an underestimation of the periodontal pocket regeneration. The last limitation of this pilot study was based on the impossibility to assess different laser parameters such as exposure time, power settings, and number of sessions. Owing to the study design (split-mouth study) we were not able to investigate different combinations of laser parameters at the same individual because the sole bactericidal effect of $H_2O_2$ photoactivation with 940 nm diode laser after SRP was not reported yet. We know from the literature that multiple sessions of laser decontamination could improve the bactericidal effect within the periodontal pockets. [16] For future research, we suggest to extend the clinical and microbiological examination at 3, 6, and 12 months after this procedure. In addition, the use of different laser parameters such as longer exposure time and a higher number of laser decontamination sessions at different intervals should be investigated.

This trial evaluated the antimicrobial effect of a new nonsurgical laser-assisted periodontal protocol for moderate to severe periodontitis with the 940 nm wavelength. The rationale of using 1.1 W in continuous mode (CW) is represented by our previous clinical findings. By increasing the power above this setting, the fiber optic tip will start to initiate in the presence of blood from the bleeding pockets or right after the bleeding from SRP resulting in removal of the inner epithelium of the pocket and losing the photoactivation of $H_2O_2$ effect.

The present results demonstrated that every investigated procedure (all groups) showed a statistically significant outcome in terms of bacteria elimination at 4 weeks postoperative (Table 5). Nevertheless, Group 3 presented statistically highly significant outcomes ( $p < 0.001$) for all the investigated parameters leading to the premise that this procedure can enhance the antimicrobial effect of SRP and diode laser decontamination.

**Table 7. Clinical Assessment of Periodontal Probing Depth and Clinical Attachment Level**

| | *PPD* | | *CAL* | |
|---|---|---|---|---|
| *Variables* | *Baseline* | *3 Months postop* | *Baseline* | *3 Months postop* |
| Group 1 (SRP) | | | | |
| Median | 6.5 | 4 | 8 | 6 |
| 25–75% | 6–7 | 3–5 | 7–9 | 5.75–7 |
| *p* | 0.000 | | 0.000 | |
| Group 2 (SRP +940 nm) | | | | |
| Median | 6 | 4 | 8 | 6.5 |
| 25–75% | 5–7 | 3–5.25 | 7–10 | 5–8.25 |
| *p* | 0.000 | | 0.000 | |
| Group 3 (SRP +H2O2+940 nm) | | | | |
| Median | 6 | 3 | 8 | 3 |
| 25–75% | 5–8 | 2–4 | 7–10 | 4–6.25 |
| *p* | 0.000 | | 0.000 | |

**Table 8. Clinical Assessment of Bleeding on Probing**

| | *BoP positive, n (%)* | |
|---|---|---|
| *Groups* | *Baseline* | *3 Months postop* |
| Group 1 (SRP) | | |
| (+) Present | 37 (97.4) | 21 (55.3) |
| *p* | <0.001 | |
| Group 2 (SRP +940 nm) | | |
| (+) Present | 36 (94.7) | 19 (50) |
| *p* | <0.001 | |
| Group 3 (SRP +H2O2+940 nm) | | |
| (+) Present | 37 (97.4) | 3 (7.9) |
| *p* | <0.001 | |

**Table 9. Clinical and Bacterial Differences Between Test and Experimental Groups**

| | *p* | | | | | |
|---|---|---|---|---|---|---|
| | *Group 1 vs. Group 2* | | *Group 1 vs. Group 3* | | *Group 2 vs. Group 3* | |
| *Bacteria* | *Preop* | *Postop* | *Preop* | *Postop* | *Preop* | *Postop* |
| TBC | 0.226 | 0.540 | 0.880 | 0.000 | 0.448 | 0.000 |
| *A. actinomycetemcomitans* | – | – | – | – | – | – |
| *P. gingivalis* | 0.823 | 0.415 | 0.526 | 0.001 | 0.282 | 0.000 |
| *T. denticola* | 0.827 | 0.743 | 0.352 | 0.000 | 0.451 | 0.000 |
| *T. forsythia* | 0.629 | 0.095 | 0.747 | 0.003 | 0.336 | 0.000 |
| *P. intermedia* | 0.679 | 0.034 | 0.282 | 0.001 | 0.352 | 0.000 |
| *P. micros* | 0.294 | 0.437 | 0.771 | 0.000 | 0.483 | 0.000 |
| *F. nucleatum* | 0.164 | 0.432 | 0.918 | 0.000 | 0.237 | 0.003 |
| *E. nodatum* | 0.333 | 0.314 | 0.477 | 0.317 | 0.964 | 0.079 |
| *C. gingivalis* | 0.346 | 0.595 | 0.750 | 0.015 | 0.544 | 0.086 |
| PPD | 0.262 | 0.201 | 0.915 | 0.023 | 0.462 | 0.001 |
| CAL | 0.800 | 0.257 | 0.799 | 0.002 | 0.577 | 0.000 |

SRP alone failed to decrease TBC ( $p = 0.124$) in contrast to Group 2 and Group 3 that successfully decreased TBC ($p < 0.001$), although Group 3 exerted a better outcome than Group 2 (Table 5).

A. actinomycetemcomitans was present in only two patients; therefore, it was not reasonable to calculate percentiles and median values, but to discuss them individually. In one patient, 1 month after SRP (Group 1), A. actinomycetemcomitans was present. The other patient presented A. actinomycetemcomitans at baseline in Group 3 and 1 month after the proposed treatment it showed complete elimination.

Although in our study the presence of A. actinomycetemcomitans was inconstant, there are other reports suggesting that conventional SRP alone is inefficient in eliminating aerobe facultative anaerobe species as A. actinomycetemcomitans and it is appropriate to combine other therapies with SRP to remove it from the periodontal pockets.[17–19] Based on this observation there is a possibility for the photoactivation of $H_2O_2$ with 940 nm diode laser to eliminate aerobe and anaerobe species like A. actinomycetemcomitans and maybe others that could not be investigated in this study.

Regarding the keystone periodontal bacteria from the red complex (P. gingivalis, T. denticola, and T. forsythia), all three groups showed high statistical results ( $p = 0.000$) at 1 month postoperative as given in Table 5.

It is well known that from the orange complex, F. nucleatum and P. intermedia have a particular role as a bridging organism between early and late colonizers.[20–22] As shown in Table 5, Groups 1 and 2 manage to reduce statistically only P. intermedia and P. micros, whereas photoactivation of $H_2O_2$ successfully eliminated all three species ($p = 0.000$), especially the bridge bacteria F. nucleatum, which is the most important bacteria from the orange complex.

C. gingivalis belonging to the green complex presented a significant decrease in only Group 1, whereas Group 2 and Group 3 exhibited an increase in C. gingivalis counts, $p = 0.275$ and $p = 0.858$, respectively. These results support the hypothesis that increased green complex bacteria are correlated to better periodontal health.[23]

From a qualitative point of view (Table 6), all three groups managed to eliminate significantly ( $p < 0.001$) P. gingivalis, T. denticola, and T. forsythia. Group 3 was the only one capable of successfully eliminating ( $p < 0.001$) the orange complex bacteria (P. intermedia, P. micros, and F. nucleatum) responsible for creating the living conditions for the strictly anaerobic bacteria of the red complex and their colonization of the periodontal pocket.[24]

All investigated groups demonstrate a statistical improvement ( $p < 0.001$) of all investigated clinical parameters like PPD, CAL (Table 7), and BoP (Table 8).

By comparing the outcomes between the investigated groups, the results demonstrated that SRP (Group 1) and SRP +940 nm diode laser (Group 2) failed to offer significant differences in contrast to photoactivation of $H_2O_2$ with 940 nm diode laser (Group 3). As given in Table 9, the results between Group 1 and Group 2 are comparable; the only significant difference can be seen in P. intermedia. On the contrary, superior differences in both antimicrobial and periodontal status improvement were seen in favor of Group 3. SRP and photoactivation of $H_2O_2$ with 940 nm wavelength was able to provide a significant elimination of the most aggressive periodontal pathogens, both in comparison with classical therapy and laser therapy proposed by other authors.[25]

Thus, the hypothesis is accepted, suggesting that photoactivation of $H_2O_2$ with 940 nm diode laser can be beneficial when used as an adjunctive antimicrobial therapy during nonsurgical periodontal treatment.

There is a concern that the ROS, including hydroxyl radicals, cause oxidative damage to cellular and oral tissues, but the use of 3% $H_2O_2$ is a safe disinfection procedure because of the rapid decomposition into water and oxygen.

Hydroxyl radical, one of the ROS, has a single unprotected electron in its structure, being capable of easily oxidizing other substances.[13] When it comes to laser photoactivation of 3% $H_2O_2$, it was demonstrated that the generation of ROS stopped immediately after the cessation of laser irradiation, 26 providing a controllable disinfection system that can be used safely in periodontal treatments.

By consulting the literature, there are few studies that have demonstrated the synergistic effect of photolysis of $H_2O_2$ with different light sources, used both in periodontal and endodontic pathology.[26–30] The most frequently used wavelength for the photolysis of $H_2O_2$ is the 405 nm LED (light-emitting diode).

The first report about the photoactivation of 3% $H_2O_2$ with the laser wavelength of 940 nm in the treatment of chronic periodontal disease was first introduced by Odor et al.[14]

Odor showed that the photoactivation of 3% $H_2O_2$ with 940 nm diode laser without combining it with SRP, can efficiently eliminate ( $p < 0.001$) periodontal bacteria like P. gingivalis, T. denticola, T. forsythia, P. intermedia, P. micros, F. nucleatum, and E. nodatum and decrease the TBC. In addition, they compare the outcomes between each investigated group (SRP, $H_2O_2$ alone, 940 nm laser alone, and photoactivation of $H_2O_2$ with 940 nm) and the study showed great significant results ( $p < 0.001$), eliminating the major periodontal pathogenic species like P. gingivalis, T. denticola, T. forsythia, P. intermedia, P. micros and also for the TBC ( $p < 0.005$) when using the photoactivation of $H_2O_2$ with 940 nm. Although their trial study was investigating the periodontal clinical indexes for a short period of time (3 months), PPD and CAL showed great improvement without using the mandatory SRP with $p < 0.005$ and $p < 0.008$, respectively.[14]

In a systematic review, Akram et al.31 evaluated the bactericidal outcomes of aPDT as an adjunct to SRP based on 17 in vivo studies. The wavelengths used by the investigated studies were ranging from 470 to 810 nm. In addition, a variety of photosensitizers were used in different concentrations. The authors underlined the importance of standardized wavelength related to photosensitizer and power densities in nonsurgical periodontal treatments.

Furthermore, they observed a significant reduction of A. actinomycetemcomitans, P. gingivalis, T. denticola, and T. forsythia when aPDT+SRP was used with higher power densities (60–400mW/cm2) than SRP alone. In contrast, lower power densities (13–75 mW/cm2) offer a comparable periodontal bacteria reduction for aPDT and SRP applications.

In our study the power density for each laser group was 1549 $W/cm^2$, therefore we can confirm their statement. Although the outcomes of the investigated articles indicate a satisfying bactericidal effect against the major periodontal pathogens (A. actinomycetemcomitans, P. gingivalis, T. denticola, and T. forsythia), the authors concluded that the bactericidal efficacy of aPDT as an adjunct to SRP in periodontal disease remains unclear. In an in vitro study, Eick et al.[32] evaluated the response of photoactivated disinfection (PAD) in 6mm artificial pockets by using 630nm LED wavelength, concerning 16 microbial species. The authors reported that after preexposure to 0.25% of $H_2O_2$ the PAD was efficiently eliminating most of the periodontal species. Nevertheless, the preexposure to $H_2O_2$ before the PAD was the only procedure that eliminated the A. actinomycetemcomitans within the biofilm significantly.

P. gingivalis, one of the most important species in periodontal disease, is successfully eliminated when using $H_2O_2$ and PAD,[27,32] which correspond to our findings, although we used the 940 nm diode laser wavelength.

## CONCLUSIONS

Within the limitations of this study we can conclude the synergistic effect of SRP and photoactivation of $H_2O_2$ with 940 nm diode laser offers an efficient and reliable antimicrobial effect in the nonsurgical periodontal treatment approach.

The suggested protocol may represent a new alternative for the 940 nm diode users in the treatment of periodontal disease, eliminating the need for local or general antibiotic administration and their side effects. Further investigation is needed for long-term results. ■

## ABOUT THE AUTHOR

**Alin Alexandru Odor, DDS, PhD, MSc**

Dr. Alin Alexandru Odor received his dental degree (DDS) from Ovidius University of Constanta – Faculty of Dental Medicine, Romania in 2012. As a student, he was int-erested in dental laser treatments and presented his graduation thesis “Study regarding the efficacy and therapeutic possibilities of Er:YAG and Nd:YAG lasers”. In 2013, he decided to pursue further research in the field of laser assisted periodontal therapy through a PhD program at Ovidius University of Constanta with cotutelle at International University of Catalonia (Spain). During his research, he developed a new disinfection system for 940 nm diode laser and a new dual wavelength protocol in the treatment of periodontal disease.

In 2014 he received his Laser in Dentistry Mastership degree from Aachen Dental Laser Center, RWTH Aachen University, Germany. From the beginning of 2015 he started his periodontology residency program at Gr.T.Popa University of

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On daily basis, Dr. Odor is performing microsurgical treatments of soft and hard tissue regeneration with high degree of difficulty.

During all this years, Dr. Alin Alexandru Odor attended national and international congresses as an invited speaker and published several articles in the field of laser in dentistry and periodontal plastic surgery.

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## AUTHOR DISCLOSURE STATEMENT

No competing financial interests exist. The authors have

no conflicts of interest to declare.

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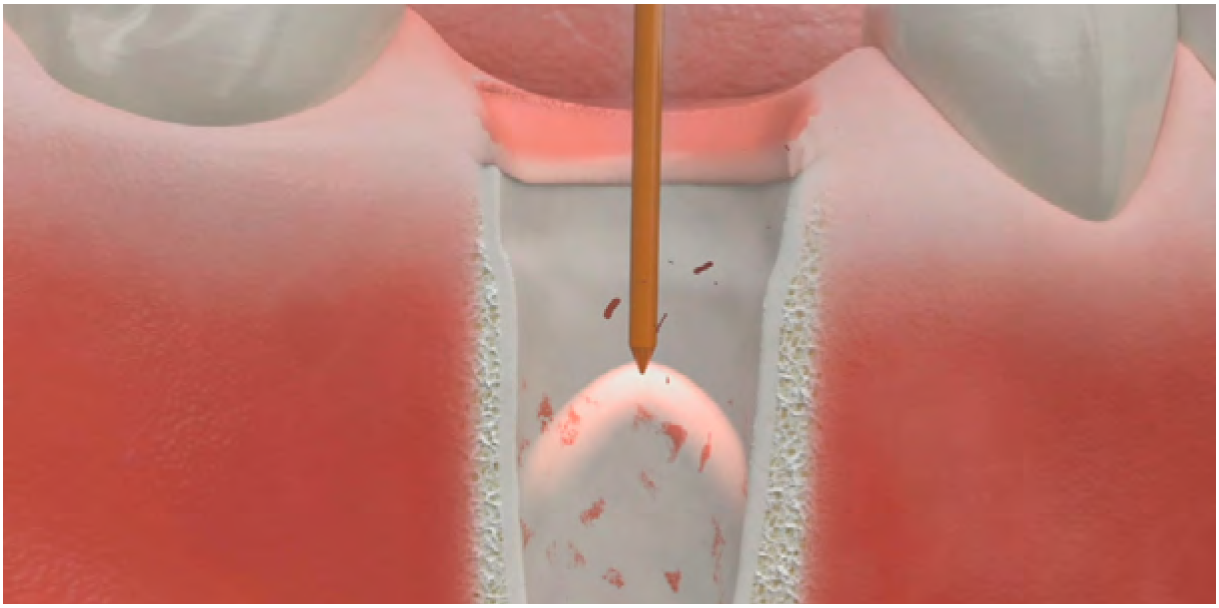
# LASER-ASSISTED SURGERY BEFORE IMPLANT PLACEMENT

## A Clinical Case Report

*By Dr. Ariel Savion*



### INTRODUCTION

The various applications of lasers in implant dentistry are dependent on the wavelength and laser–tissue interactions. Lasers have been used for many years in oral surgery and implant dentistry. In some cases, laser treatment has become 'state of the art', compared to conventional techniques. To understand the indications for lasers in surgery, it is necessary to know the fundamental principles of laser light.

Erbium lasers, such as Er:YAG and Er,Cr:YSGG wavelengths, have two main chromophores, water or the hydroxide ion (OH-) as primary, and mineral Hydroxyapatite as a secondary. They emit in the mid-infrared range at wavelengths of 2,940 nm for Er:YAG and 2,780 nm for Er,Cr:YSGG, respectively. Due to their significant absorption in water, their penetration depth can be as shallow as 5µm[1]. Erbium laser systems have free-running pulsed emission modes with peak powers measuring thousands of watts. Thus, they offer ablation with minimal thermal side effects. The photonic energy of both the Er:YAG and Er,Cr:YSGG lasers can be delivered in either a contact or non-contact mode. In contrast, diode lasers emit wavelengths of 445, 810, 940 and 980 nm, have default continuous wave emission mode, deliver energy in contact mode only and, therefore, have higher thermal side effects on the soft tissues.

Unlike other light sources, lasers emit coherent, monochromatic and collimated electromagnetic radiation which enables their use in unique surgical applications. Whether a laser system is suitable for incisions, vaporization or coagulation is determined by the wavelength, the energy density (fluence), the optical characteristics of the tissues and mode of operation. In continuous mode, the laser provides a constant and stable delivery of energy. Pulsed laser systems, in contrast, provide bursts of energy.

Lasers in the ultraviolet region (100 to 380 nm) are capable of ionizing tissues, a process known as photochemical desorption. Lasers of longer wavelengths, especially those within the infrared part of the spectrum (700 to 11,000 nm), cause significant tissue heating.



JLAD is presented for the research and investigative benefit of dental professionals utilizing lasers for dentistry.
Please refer to your laser user manual for specific instructions and indications for use.

## CASE REPORT CANINE #13

### CLINICAL EXAMINATION

A 66-year-old female, presented with broken old PFM crown on tooth #13, without minimum ferrule and resistance form. Her chief complaint was the crown falling out often. Her demand was new restoration on this tooth.

In clinical investigation, her medical history was non-contributory, she was a non-smoker or alcohol consumer. Dental history was significant for poor oral hygiene with localized areas of dental plaque-induced gingival inflammation. Normal thickness and width of keratinized mucosa was noted with deep occlusion. On CBCT observed long root with periapical lesion and thin buccal plate < 1 mm (Figure 1).

### SUGGESTED TREATMENT PLAN

**A.** Laser-assisted partial tooth extraction performing socket shield technique[2] to avoid buccal plate dehiscence.

**B.** Laser-assisted apical resection.

**C.** Laser disinfection and guided implantation (immediate implant placement using surgical guide). (Figure 2).

## TREATMENT PLAN

Based on our clinical findings, performing crown lengthening surgery and crown replacement will extend the life expectancy of the tooth, but will cause unaesthetic appearance. Moreover, minimal remaining tooth structure and presence of periapical lesion will reduce success rate and restoration durability. In esthetic zone, we must preserve both hard and soft tissues and, therefore, the preferred treatment plan will be to perform immediate extraction and implant placement with loading for soft tissue seal and emergence profile.

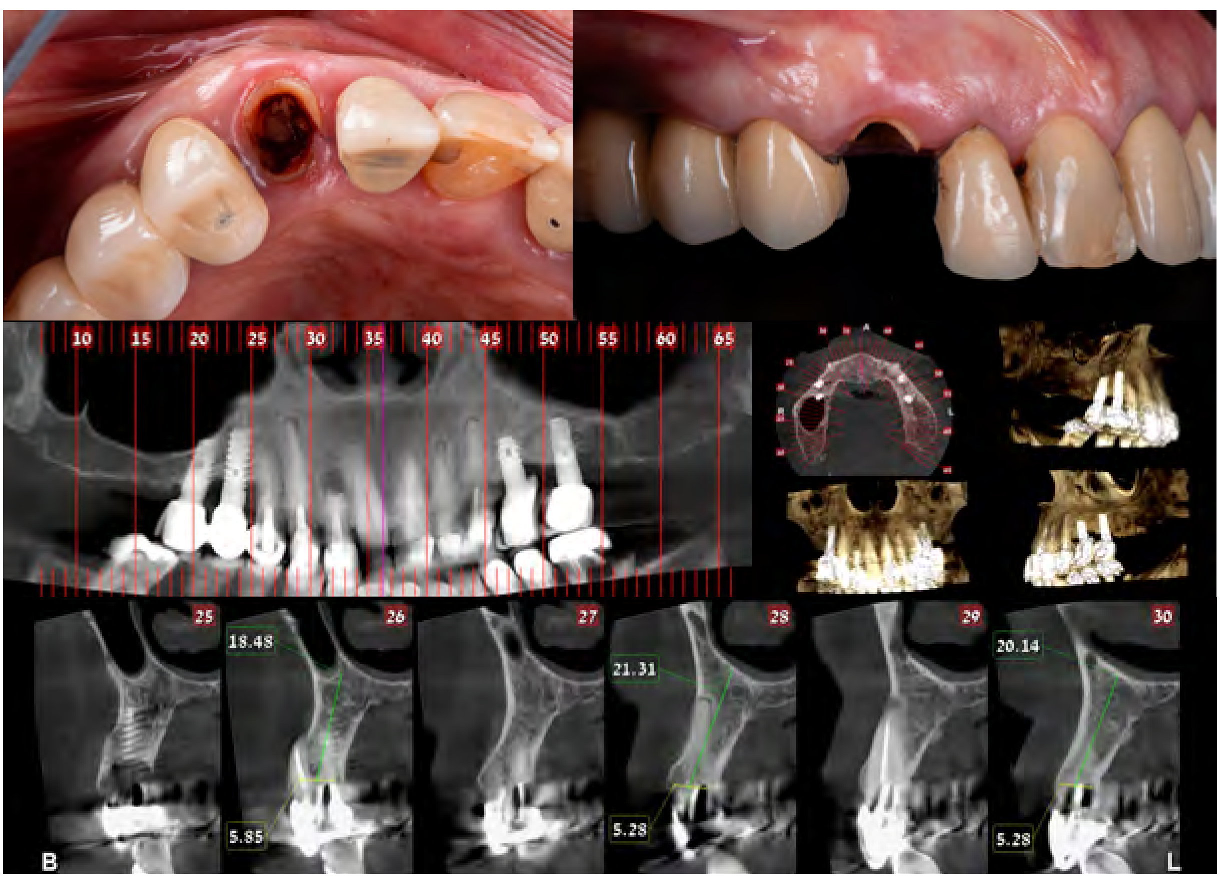



**Fig. 1** Pre-operative CBCT of tooth 1.3 with periapical lesion and thin buccal plate.

## SURGICAL PROCEDURE

1. Extraction of tooth #13. No antibiotics were prescribed prior to or after the surgery[3]. Local infiltrative anesthesia was administered (Lidocaine 2%, Epinephrine 1:100,000).

2. Mucoperiosteal flap was performed without full papillae elevation with 2 vertical incisions.

3. Partial tooth extraction was performed following granulation tissue removal with Er,Cr:YSGG laser. Debridement time was proportional to the amount of pathological tissue and bone volume, while ensuring no physical contact between the laser tip and the hard tissues. (Figure 3)

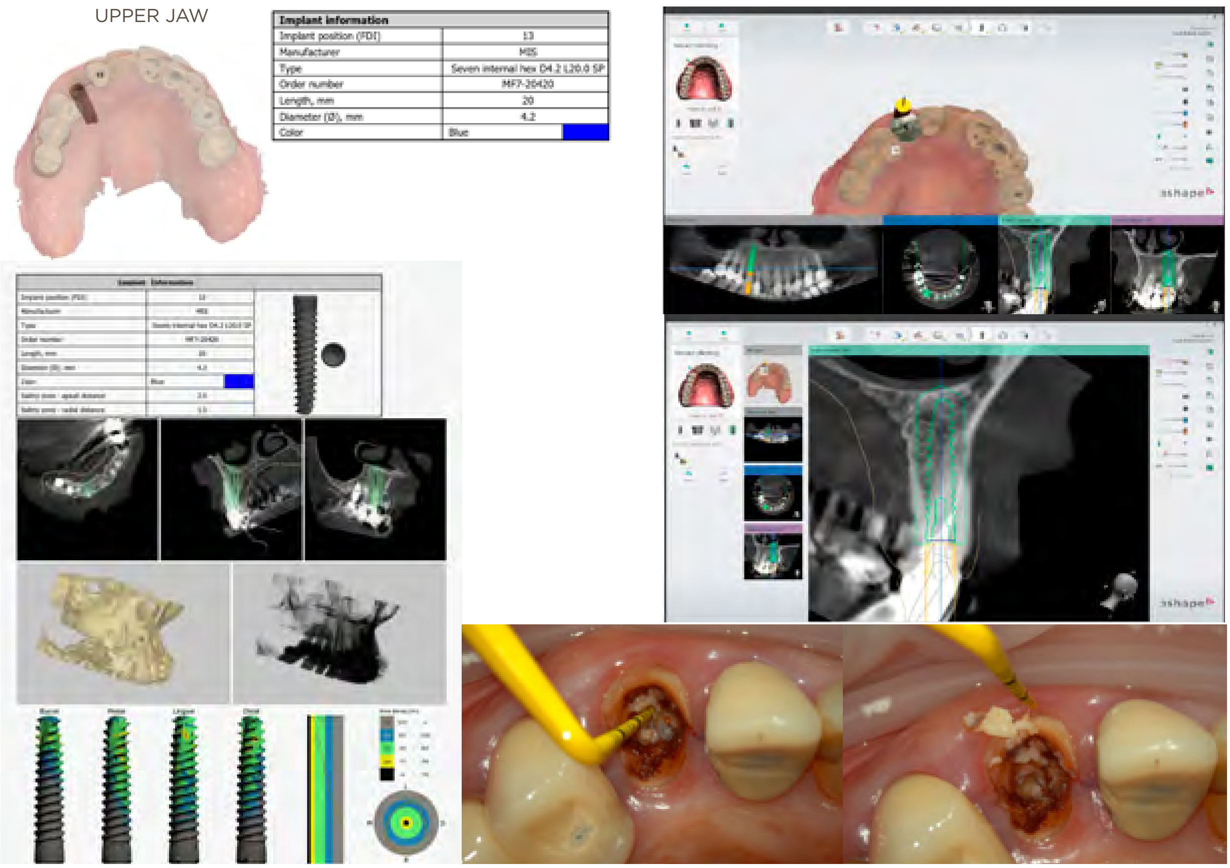



**Fig. 2** Surgical Guide – long root with very thin buccal plate.

## **ER,CR:YSGG LASER** TISSUE INTERACTIONS

The proposed advantage of the use of lasers in implant dentistry is improved hemostasis, precise incision margin, minimal damage to the surrounding tissues, and reduced postoperative swelling.[4]

A laser device emits light through a process called stimulated emission. Laser irradiation is mainly characterized by wavelength, exposure time, pulse frequency, pulse duration, spot size, power, and energy density. Tissue properties are characterized by optical, chemical, mechanical, and thermal qualities.[5] Among optical qualities especially coefficients for absorption, reflection, refraction, and scattering are important in determining laser beam transmission and, therefore, absorption.[6]

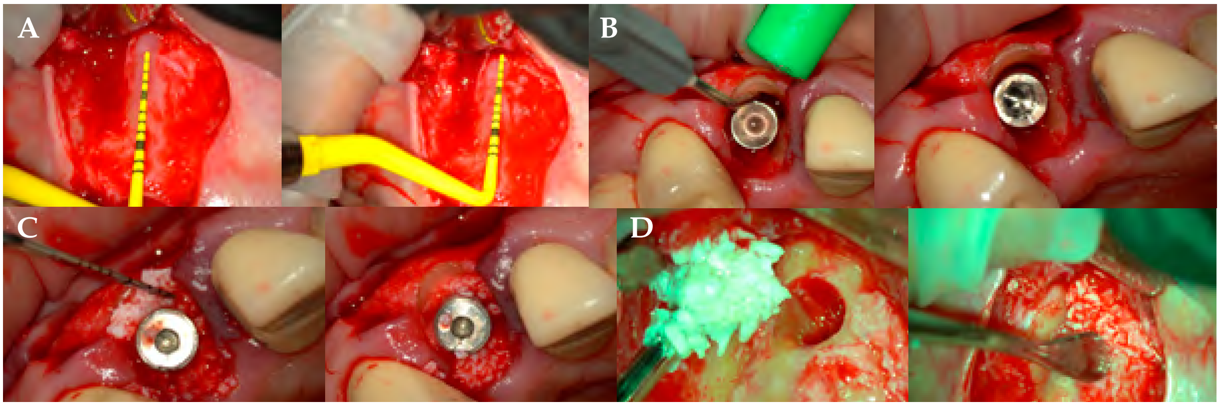



**Fig. 3** Surgical phase A: long root with thin buccal plate and periapical lesian. B: implant insertion, perserving space between root and implant. C: xenograft particles gap filling. D: after laser-assisted tooth resection, xenograft bone augmentation.

## LASER PARAMETERS

In this case report, has been applied laser erbium, chromium: yttrium scandium gallium garnet (Er,Cr:YSGG) 2780 nm (Waterlase iPlus®, BIOLASE, Irvine CA, USA), Waterlase Gold Handpiece, new tip MZ-6, 17 mm length. The laser parameters utilized as follows:

- Granulation tissue removal - the average output power 2.0 W, pulse duration of 60 µm (H-mode), pulse repetition rate of 30 Hz under water spray (air: 20%, water: 40%.)
- Osteotomy - average output power of 6 W, pulse duration of 60 µm (H-mode), pulse repetition rate of 50 Hz under water spray (air: 40%, water 90%)
- Laser-assisted root resection - output power 7 W, pulse duration of 60 µm (H-mode), pulse repetition rate of 20 Hz under water spray (air: 50%, water: 90%)

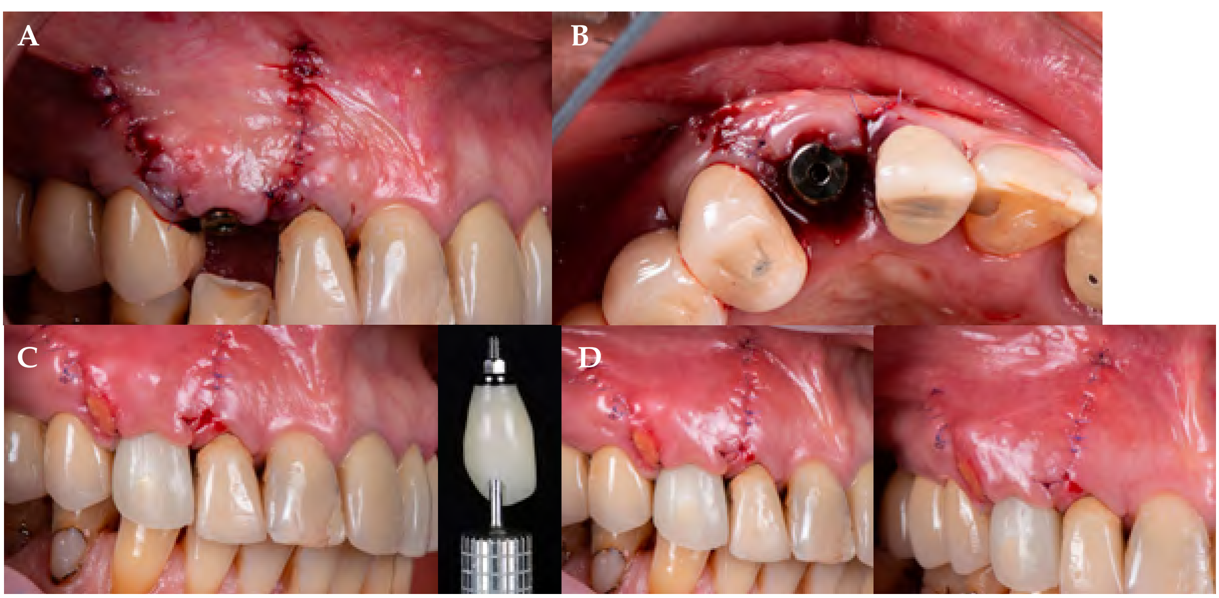



**Fig. 4** Follow up and immediate loading A: sutures monofilament 7.0 on surgery day. B: occlusal view, volume preservation with partial tooth extraction. C: healing process after 5 days. Insertion temporary PMMA screw retained crown. D: immediate loading after 5 days. Lateral view.

**Fig. 5** *From left to right* — Emergence profile before final restoration. Final zirconia crown cemented on zirconia abutment.

## PROSTHETIC PHASE |

Esthetic compromise can present itself as vertical recession in the mid-facial or interdental areas, loss of facial contours in the horizontal dimension and differing tissue color and surface texture.[7] These consequences of tooth extraction are caused by mechanical trauma, microorganisms in the socket exposed to the oral cavity, disruption of the periosteal blood supply after flap elevation and patient-related risk factors such as smoking or plaque accumulation,[8] thickness of the buccal bone wall and the loss of periodontium.[9] (Figure 4-8)

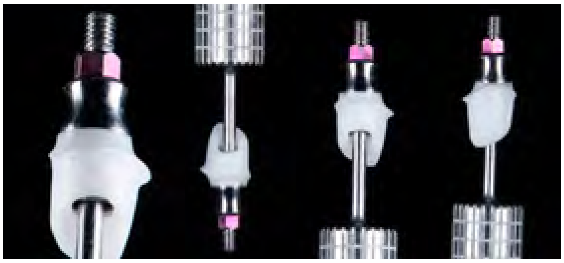


**Fig. 6** Custom designed and milled zirconia abutment on T-Base before insertion.

An esthetic implant-supported restoration emerges through the surrounding tissues mimicking a natural tooth.[7] The transition between the restoration and the soft tissues must appear natural and the emergence profile (EP) often requires customized modification.[10] The correct contour of the provisional restoration is essential to achieve an esthetic result.[11] Development of the emergence profile by manipulating the peri-implant tissues should be performed at the temporization stage.

The peri-implant tissue complex varies based on implant design, position, soft tissue quality, and the osseous structures, and it is impossible to standardize abutment designs for all cases.[12]

## DISCUSSION

### ER,CR:YSGG LASER IN IMPLANT DENTISTRY.

Crippa et al. evaluated the feasibility of YSGG laser irradiation on infected and/or inflamed post-extraction sites for the immediate placement and, when possible, immediate loading of endosseous implants.[13] It was found that the combination of mechanical, chemical, and laser treatment

**Fig. 7** *From left to right* — Insertion of zirconia abutment before final restoration. Final zirconia crown cemented on ziconium abutment.

was highly effective for the disinfection of post-extraction sites. YSGG laser is useful not only as a surgical device but also as a disinfection tool, ensuring optimal results after implant surgery.

In the review of current literature, along with clinical procedures, outcomes and incidence of complications associated with placement of immediate implants into infected post-extraction sites, Crippa et al. found the YSGG laser was able to significantly reduce the bacterial concentration following extraction of compromised teeth.[15] It was concluded that the use of YSGG laser has ensured success of implant therapy performed in an infected site and prevented complications such as peri-implantitis. The implant achieved good primary stability, immediate placement into an infected site did not increase complications and the 5-year follow-up confirmed the treatment success.

Gutknecht et al.[3] noted that in the presence of chronic periodontal disease prior to tooth extraction, YSGG laser produced very high bactericidal effect and made the laser treatment an indispensable part of periodontal treatment. This approach can be used in flapless technique when we extract the tooth and disinfect the infected socket with this laser before implant placement without raising the flap. A 360-degree radial firing tip can significantly reduce pathogenic microorganisms in the periodontal environment. Microbiological examinations showed a strong reduction of the entire bacterial burden in the pocket as well as each separate periodontal pathogen which persisted up to six months after treatment. The pocket depths of the treated sites showed greater reduction after using the laser than in the non-lased sites.

For the improvements in the treatment outcome of surgical therapy, including regenerative surgery, preparation of the diseased site by better decontamination methods and activation of the surrounding tissues/cells may be required. High-level power and low-level power lasers offer promise in this regard by helping inflamed and/or damaged tissues to rapidly move into the healing and regenerative phases by thorough debridement and decontamination and by modulation of cellular metabolism in the surrounding tissues. [16]

With respect to the implant site preparation, Er,Cr:YSGG laser application has been proven to facilitate implant placement and achieve faster osseointegration with less osseous tissue damage when compared to conventional bur drilling.[17]


**Fig. 8** Final outcome, treat duration 3 months from surgery day. LANCE implants (MIS, Israel), diameter 3.75 mm, length 16 mm for promary stability and immediate loading.

## CONCLUSION

In this case report presented, immediate dental implant placement has numerous advantages. Laser assisted surgery reduced treatment time, and cost and enhanced patient comfort with less morbidity. Less extensive surgical interventions needed. Likewise, using advanced laser technology in implantology decreased bone resorption, preserved soft and hard tissue volume, and offered the ability to deliver natural-looking of final esthetic restoration in short period time. Furthermore, minimal invasive approach encouraging anxious patients be treated with advanced laser technology.

With respect to the implant site preparation, Er,Cr:YSGG laser application has been proven to facilitate implant placement and achieve faster osseointegration with less osseous tissue damage when compared to conventional bur drilling.[17] ■

## ABOUT THE AUTHOR

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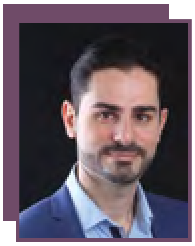

Ariel Savion is a board certified diplomate in oral Implantology (ICOI - USA),

Expert in oral implantology (ICOI - EUROPE)

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“Mastership” and “Master of Science” in laser in dentistry at Aachen University.

“Mastership” In laser assisted dentistry by World Clinical Laser Institute - WCLI

Dr. Savion a board member of the International Association Microscopic Dental Club that promotes microscopic dentistry worldwide. Dr. Savion is the owner of the “Savion Study Club”, a learning platform in “laser assisted microscopic surgery & dentistry”. In his private clinic, he focuses in laser assisted Implantology and aesthetic dentistry in a minimally invasive approach. Moreover, Dr. Savion is a dental photographer under microscopic magnification that highlights his passion and precision in the dental and surgical field.

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# Is This Vision Important for Dentistry?

## The Role of Erbium and Diode Laser System in the Treatment of Oral Frenula and its Contribution to Breastfeeding

*By Dr. María del Pilar Martín Santiago, DDS, MSc Lasers in Dentistry, Expert in Dentistry for Newborns*

*Oral Health*, September 5, 2018

### INTRODUCTION

Breastfeeding has an important role in the development of the orofacial structures in babies. For this reason, we need to review our knowledge and the importance of the mouth in the success of breastfeeding and in the growth of the infants and, on the other hand, the role of laser systems in a minimally invasive management of oral disorders and pathologies.

In the first world countries of the 20th century, we observed a significant decrease in breastfeeding, which contributed to an increase in orofacial imbalances. Fortunately, from the end of the 20th century and continuing now, we are experiencing the resurgence of breastfeeding. In many cases, breastfeeding problems for mothers and babies are attributed to abnormal attachments of the tongue or the upper lip (such as tongue tie and lip-ties). Other problems like epulis, tumors, angiomas or natal teeth can be considered to be primary factors in creating breastfeeding difficulties, they alter the correct function of the mouth of the baby.

This means that pediatricians and breastfeeding experts, together with expert dentists in neonatology, must create multidisciplinary teams to study cases in which the mouth becomes an impediment to the proper development of breastfeeding.

We must carefully study each case and check for a restrictive pattern that is the cause of the difficulty in breastfeeding, as this is vital for the integral development of the newborn.

There is a strong belief or axiom that we must wait until the child has grown to perform a frenectomy, but sometimes when we do not do it, it may affect the future growth process itself and limit the infant's own development.

**Fig. 1** – Complete sealing during breastfeeding, shape of the lips in "C".

### DISTURBANCES CAUSED BY NOT BEING BREASTFED

We have to take into account that oral health is an important part of the breastfeeding experience [1,2,3,4,5,6,7] and breastfeeding is not only a lifestyle choice, but rather a basic health need. When we do not have proper type of nutrition, we can observe some problems in the development of babies. We associate the following problems with babies who were not breastfed: dental malocclusions, high palates, narrow dental arches, anterior & posterior dental crossbites, inadequate nasal respiration, alterations in the deglutition and in the management of the tongue, inadequate facial development, incorrect mastication pattern, parafunctions, thumb sucking or problems in the emotional sphere.[4,5,8]

JLAD is presented for the research and investigative benefit of dental professionals utilizing lasers for dentistry.
Please refer to your laser user manual for specific instructions and indications for use.

Newborns often present with ankyloglossia (tongue tie) or lip-tie which cause problems in breastfeeding. Ankyloglossia is associated with 25-60% of the incidence of difficulties during breastfeeding for mothers and babies. [9,10]

## THE IMPORTANCE OF BREASTFEEDING
### THE NIPPLES AS EXPANDERS OF THE PALATE

Alterations in oral structures allow us to understand the importance of the breastfeeding experience, because the "Nipples are considered like Mother Nature's palate-expanders". As babies push the nipple behind the front teeth and push on the palate, they develop a wide and forward palate and enough room for the permanent teeth. On the other hand, peristaltic movements (in bottle feeding, piston movements) [11] produce the first physiological advance of the mandible, connecting the jaw, hyoid bone and cervical spine in a harmonic three-dimensional position.

The benefits of breastfeeding in the development of orofacial structures, allow infants to naturally breathe and swallow at the same time without learning a complicated protective mechanism.

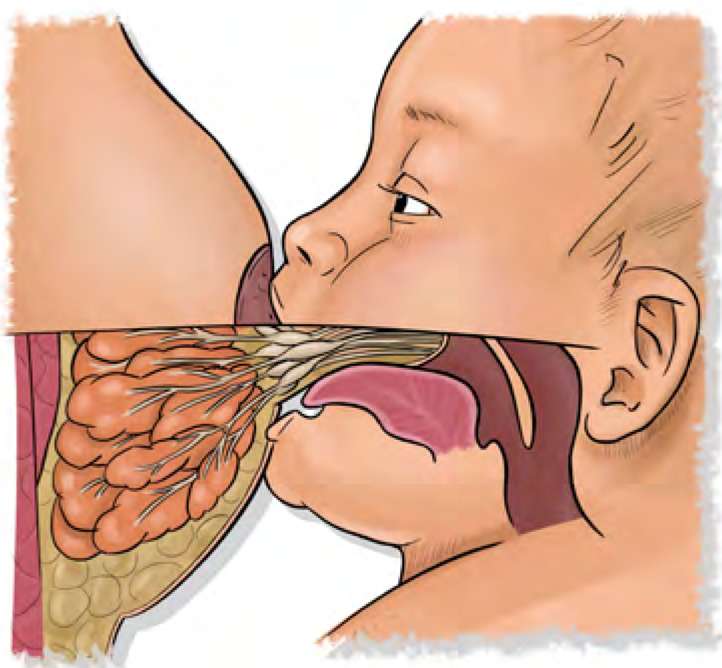

**Fig. 2**

### BREASTFEEDING BENEFITS TO INFANTS:

- it improves the infant's immune system
- prevention of allergies
- no preservatives as it is always fresh
- emotional attachment to the mother
- it protects against gastroenteritis, constipation and other stomach illnesses
- it reduces the risk of SIDS (sudden infant death syndrome)
- promotes proper facial development
- reduces the risk of heart disease or obesity as teenagers and adults
- babies who are breastfed have fewer indicators of malocclusion problems, oral breathing or poor orofacial development. 8

In the future, adults with ankyloglossia will have more problems with snoring and nocturnal apneas, because the tongue goes backwards during sleep, closing more airway space.

### SYMPTOMS IN BABIES

We can observe:

- Restricted tongue movement where the baby may be unable to poke his tongue out or lick his lips, and during crying the tongue may remain in the floor of the mouth or just the edges may curl up forming a 'dish' or a whale tail shape.
- Poor wave motion
- It is possible that baby is unable to open the mouths widely when attaching to the breast, resulting in a biting/grinding behavior and a tight labial frenulum which does not allow flanging of the lips
- Unsettled/fussy behavior when latching to the breast and during feeds
- Coughing on the milk flow
- Difficulty staying attached to the breast. The nipple slides off
- No latch or un-sustained latch

- Falling asleep at the breast before the end of feeding
- Frequent or very long feeds
- Excessive early weight loss/poor weight gain/ faltering growth. Excessive weight loss in the first few days of life, or slow weight gain later on, despite constant feeding
- Clicking noises and/or dribbling during feeds
- Failure to thrive
- Colic, wind, hiccups
- Reflux (aerophagia)
- Gumming or chewing the nipple
- Unable to hold pacifier

There are many other symptoms and signs in the neonatal period and during childhood.

## DIAGNOSIS OF FRENULUM DISORDERS

For the diagnosis of frenulum and oral disorders in babies, we need to study the clinical history of baby and mother, type of delivery, maturity…etc. and a clinical exploration of all the structures of the child and mother which are involved in Breastfeeding. For example, checking the condition of the baby's mouth by assessing: tongue, gums, jaws, lips, epiglottis and soft/hard palate. It is also important to take a look at the oral-nasal respiratory circuit and pattern.

We need the important information provided by the pediatrician about the baby. In addition, we need to carefully examine oral frenula, breathing and the neurological reflexes correlated with breastfeeding and with the maturity of babies. A child with neurological immaturity cannot perform adequate suction, even if we control his frenulum. [6]

## HOW TO DETERMINE IF YOUR NEWBORN INFANT IS TONGUE-TIED

Ankyloglossia or lip tie can be defined in different ways:

- Anatomic & clinical appearance.
- Restrictive movements and functional ability.
- Infant and mother symptoms: loss of weight, inability to breastfeed properly, pain in the nipple, mastitis… etc.

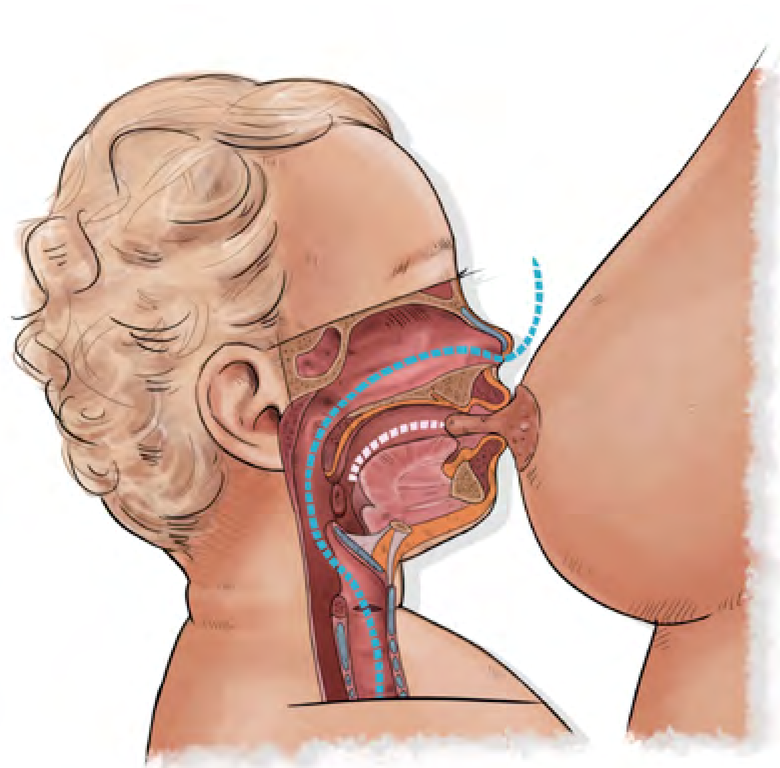

Fig. 3

There is no universally agreed upon way to classify tongue or lip-ties, therefore, there are different frenula classifications. However, in our experience, we believe it is more appropriate to simplify everything and classify the presence of ankyloglossia in:

### 1. NORMAL:

- Normal appearance.
- Insertion of the frenulum well below the tip of the tongue and closer to the base than to the tip (approximately 1 cm) and inserted into the floor of the mouth close to the insertion of the genioglossus muscle.
- Correct mobility both to the front and in lateral movements.
- No symptoms of restriction.

### 2. MILD RESTRICTION:

- Normal appearance.
- Insertion of the frenulum under the tip of the tongue and towards the floor of the mouth, being able to have a “trident” that anchors it in the lingual part of the alveolar ridge.

Fig. 4 – Double upper Labial frenulum in a baby.

- No important symptoms of restriction.
- The length of mobile tongue is 12-16 mm.
- The restriction is between 0.22 - 0.39 with good mobility of the tongue.

### 3. MODERATE RESTRICTION:

- The appearance of the tongue presents slight retraction of the tip or tendency to have a shape of the tail of a whale, and to position itself down when resting.
- The insertion of the frenulum is very close to the tip of the tongue and towards the floor of the mouth with a strong trident towards the alveolar ridge or in the alveolar ridge.
- Limited mobility both to the front and in lateral movements.
- When we provoke the suction introducing the finger in the mouth of the baby, we appreciate that the tongue has difficulties to surround and suck the finger, sometimes with a complete loss on the back of the finger, where there is a reverse movement (peristalsis), like a wave that is sailing backwards.
- Reversion of the sound or clicking occurs when the tongue loses contact with the finger and, therefore, loses the negative pressure.
- It is not very elastic.
- With symptoms of restriction.
- Length of mobile tongue 8-11 mm.
- The Restriction is between 0.14- 0.22 with limited mobility of the tongue.

### 4. SEVERE RESTRICTION:

- The appearance of the tongue presents strong retraction of the tip with complete hold of the tongue to the floor of the mouth or to the alveolar ridge.
- Heart-shaped, with the central part of the tongue very depressed, with tendency to place itself down in normal position.
- The insertion of the frenulum is at the tip of the tongue.
- Very limited mobility both to the front and in lateral movements.
- The tip of the tongue cannot ascend without closing the mouth and with a broad (heart-like) shape, with an important depression in the center of the tongue.
- The frenulum has less than 1 cm when the tongue is extended.
- There are signs of ischemia in the insertion of the tongue when we pull from it.
- It cannot be positioned on the lower lip.
- When we provoke the suction introducing the finger in the mouth of the baby, we appreciate that the tongue has serious difficulties to surround and suck the finger.
- It is very often seen the reversion of the sound or clicking that occurs when the tongue loses contact with the finger and, therefore, loses the negative pressure.

- It is relatively inelastic.
- With severe symptoms of restriction.
- Length of mobile tongue is smaller than 3 mm.
- The restriction is close to and below

## TREATMENT OPTIONS FOR LIP AND TONGUE-TIES

- Myofunctional treatment.
- Frenotomy, Frenectomy or Z-plasty:
- With conventional surgery, these procedures are usually more aggressive and more uncomfortable after surgery. There is more bleeding and need for sutures.
- There is high incidence of recurrence/relapse.
- With laser systems, the treatment is minimally invasive, little to no bleeding, no sutures, quick recovery, low to no recurrence of the problem.
- Laser is a great option as some babies can be Vitamin K deficient.

## FRENOTOMY AND FRENECTOMY TECHNIQUES WITH LASER SYSTEMS

- The child is swaddled with a blanket to control movements.
- Good control of patient's airway.
- Safety glasses with elastic strap according to Laser Safety Standards: ANSI 136.1(USA) and EN207/ EN208/EC60825 (Europe).
- Assistant holds and stabilizes head.
- Stabilize and elevate tongue.
- No anesthetics.
- Ablate the center of frenum (~1 cm). Frenum is poorly vascularized and is poorly innervated
- Infant can breastfeed immediately.
- Completed in dental chair in 2-3 minutes.

It is very important for the infant's safety and for a good visualization of the surgical area to have a well-trained staff

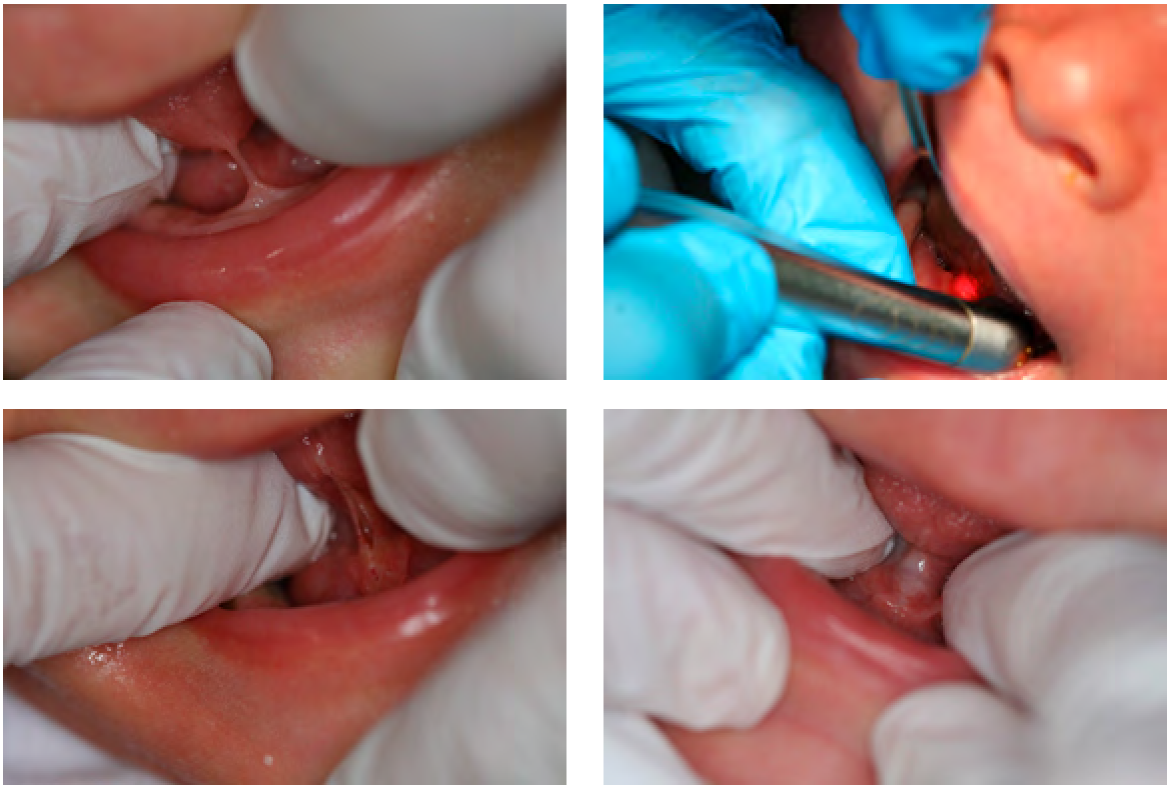

**Fig. 5** – Surgery for tongue tie release with Er,Cr:YSGG laser

to properly hold the infant and assist in maintaining a good airway. It is imperative to locate the mamelons where the holes of the outflow of the Wharton ducts are located, as they are excretors of the submaxillary salivary glands. We can use the fingers or the Lorenz tongue holder or groove director (Tongue lifter) to help position the tongue.

Different laser systems, like the diodes or erbium lasers, can be used to perform this surgical procedure, as reported by several authors in recent publications on this subject. [12,13,14,15,16,17]

In my opinion, Erbium laser is more comfortable for the babies. We don't need anesthetic or sutures, we don't have bleeding, we have precise control over the important surrounding structures, like the glands, and there is no recurrence.

- Diode Laser 940 nm: pre-initiated tip is used in direct contact with tissue at a power of 2.0 W CW using a 400 µm fiber.
- Er,Cr:YSGG, 2780 nm: 2-3 Watts, 50 Hz, H/S Mode, 20% air, 20% water, tip MZ5 or MC3. Around 50-70 mJ/cm$^2$ of fluence.

In most cases, 2-8 mm of freedom is adequate to allow an improved and comfortable nursing.

## POST-OPERATIVE CARE INSTRUCTIONS

- 1 month after surgery, control by a myofunctional therapist expert in neonatology.
- Pull in the morning and at night. 2-3 times per day for 2 weeks, beginning 1 week after surgery.
- Rinsing the mouth with warm salt water.
- Hyaluronic gel.
- Auxin A+E, oil pearls.
- Cranial-Sacral therapy.
- Pediatric ibuprofen, if the baby has some discomfort.

Our mouths are very important for our lives! Dentists are in the unique position to help our youngest patients to start their lives on the right foot (or with the right mouth). Are we as a profession ready for this challenge? ■

## ABOUT THE AUTHOR

**Maria del Pilar Martin Santiago, DDS, MSc**

Dr. Pilar Martín graduated in 1987 from the Universities of La Laguna (Spain) and Universidad Odontológica Dominicana (Santo Domingo) with degrees in Medicine, Surgery and Dentistry. In 1996, Dr. Pilar completed her Post Graduate Course in Cosmetic Dentistry at the Baylor Collage of Dentistry in Texas. She has also been trained in the field of surgery with the Master in Implantology, Surgery, Periodontics and Prosthodontics in the University of Bern (Switzerland) in 2002.

In 2010, she completed the European Master Degree in Oral Laser Applications at the University of Barcelona and EMDOLA. After that, she received her Master of Laser in Dermo-aesthetic Pathology at the University of Barcelona. She holds Master of Science degree in Laser Dentistry from RWHT University in Aachen, Germany, and is the Official Representative for AALZ (Aachen Dental Laser Center) in Latin America and Spain. Dr. Pilar has attained Mastership certification in WCLI (World Clinical Laser Institute) in 2011 (Baltimore, Maryland) and recently, she was named the Official Representative of the WFLD (World Federation for Laser Dentistry) in Spain to Official Representative of AALZ in Spain and Latin America.

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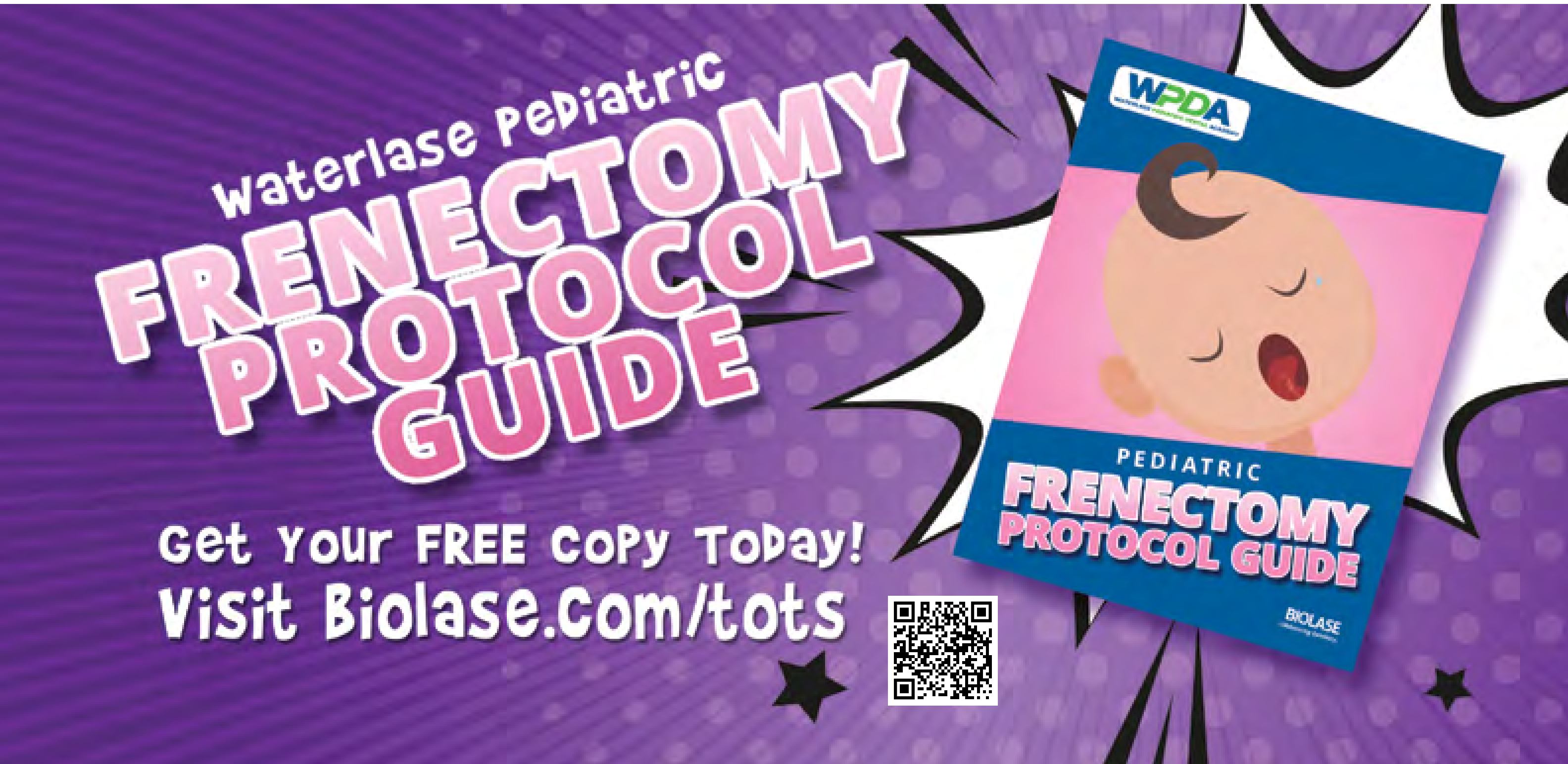

# MEET THE MASTERS

## Dr. Premila Suganthan

Hello, my name is Dr. Premila Suganthan, and I am a dental surgeon with 25 years of expertise in cosmetic, implant, and laser dentistry. Professionally, I am termed as a laser dentist in South India. My roots lie in Chennai, where I completed my bachelor's degree in 1994, graduating from RMDC & H, Annamalai University. I did my initial trainings in Laser Applications in the World Clinical Laser Institute (WCLI), Taipei-Taiwan. This further sparked my interest in lasers and drove me to eagerly take the diploma and certificate program in laser dentistry from AALZ & RWTH Aachen University at IALD, Mumbai in 2009.

My humble thanks to my mentor, Dr. Suchetan Pradhan, for providing me with this wonderful opportunity. Thank you for bringing the best out of me, for tapping into my talents, and for assisting me in focusing and highlighting those talents into the best possible platform.

My thirst for laser knowledge was not lightened after these courses, but rather it became fiercer, as I pursued my "Advanced Application and Techniques in Laser Assisted Dentistry" training at University of Queensland, School of Dentistry, Brisbane, Australia. Combined with this training, and to master the laser arts, I completed my fellowship in Laser Dentistry from University of Genova in September of 2012 and then my Masters in Laser Dentistry (M.Sc) from University of Genova in 2013-2014. All this experience culminated in September of 2017, a milestone in my life when I became the first Indian to achieve the mastership in laser dentistry from the World Clinical Laser Institute, Seoul. It kindled, within me, much excitement because it was created a huge opportunity for laser education. This paved the way for conducting the associate fellowship program for WCLI in India, with me as the principal instructor, on behalf of executive director of WCLI, Dr. Chris Walinski. I felt very privileged for the trust they had in me to conduct this special program, the first of its kind, in My Country.

> *"Alone we can do so little; together we can do so much."*
>
> *- Helen Keller*

With my mastership of lasers, and laser education blossoming in India, I later expanded my clinical horizons further, towards a fellowship in Facial Aesthetic and Cosmetology, from the Council of Cosmetology and Aesthetic Science. With this fellowship, the last piece of the puzzle, if you will, I was able to reach the pinnacle of care in my practice, *KP Tooth Care Clinic – Laser Assisted Dental Practice*. The vision for my practice was that it would not just be a dental clinic in the traditional sense, but rather that it would be a temple of worship where all my passion, hard work, and learnings would manifest into something truly special.

My journey with Er,Cr:YSGG started in 2008 with my first experience with an all-tissue laser at WCLI-Taipei. This sparked additional curiosity that endured into my own dental practice. I was galvanized to use this magic device, even though the Er,Cr:YSGG laser seemed like such a new, radical technology in India. I, however, wanted to try to re-invent the wheel of dentistry. So, without a second thought and with massive personal risk, I purchased the Waterlase laser from BIOLASE in 2009, as a partial celebration of my 10th year of clinical practice. As I was the only practitioner using laser at that point in time, and simultaneously being brand new to lasers, I could have easily gotten overwhelmed and frustrated. I did not quit, however, and my passion carried me to fight through the challenges and master the techniques of laser dentistry. I came to know for certainty that BIOLASE had my back, also, because when my laser was shutting down due to intense humidity and tropical weather, they immediately rushed in to support me and assist me with getting my machine back up and running. A quote that stands out to me, as I think about these moments, is, "***Teamwork divides the task and multiplies the success.***" Thank you to the BIOLASE team for your extended support, all through my career. You stood by me, and I greatly appreciate it.

In dentistry, my mission is to build a long-lasting relationship, to exceed my patient's expectations, to provide a high-tech facility in the field of dentistry, and to create a difference in each patient's life. I practically live with lasers (laugh) in all the procedures, like full mouth rehabilitation, implants, periodontal surgeries, endodontic procedures, TMD and cosmetic dentistry. "Painless dentistry" is the term predominantly used by my patients when it comes to procedures assisted with Waterlase. To my surprise, pediatric patients are more attracted to its popping sound during cavity preparations and call the laser a "***popcorn machine – the magic light***".

I always seek to keep myself updated on the latest techniques and technologies. Continually educating myself, every day, keeps me lively and helps me feel refreshed throughout the years. The activity of updating my practice with the latest technologies of digital dentistry and experimenting with the latest equipment is a critical part of my day-to-day purpose. However, I do try to take time for myself and my family, also. During my leisure time, I go for a brisk walk to make myself rejuvenated and keep me active. Long drives with my family and exploring new places drives me crazy and make me feel young (*shhh .. I always feel like I am Sweet-16 LOL*). My most relaxing hobby is to do yoga, which keeps my mental and physical health sound. I am positive that nothing is as powerful and motivating as deliciously cooking foods, I feel spending time with my family could really boost the mood up for a few extra hours of hustle. It is the hustle, that gets the results and makes you run. My love for painting is never ending. During a long gap during the lockdown days, I got a chance to spend my valuable time to invest in painting. I ensure to spend productive hours with my daughter in observing/supporting young talents on horse riding at Madras School of Equitation. Apart from all this, philanthropy has proved to be a most popular activity that makes me joyous and contented, as I'm an active member of rotary club.

Being a successful practitioner for more than 25 years, my services never end with just treating patients, but I always ensure to pass on my knowledge about lasers with dental colleagues through my institution, *KP Institute of Laser*

*Studies*, my avenue for sharing knowledge for more than a decade. Under the able mentorship of Dr. Pradhan, we have educated and trained dental practitioners and students, with a safe and successful practice of laser dentistry, at various renowned universities, such as Manipal, DY Patil, and Saveetha University in various regions in India.

Whether Waterlase is a magic wand or not, this laser is a life-changer in my dental practice, providing 100% patient satisfaction. Any optimal services or treatments does not end without the role of Er,Cr:YSGG lasers in it. Our vision is to provide our patients with a dental and laser experience that will promote a lifelong relationship built on trust, confidence, quality of work, and exceptional patient care. It is also our responsibility to strive to remove barriers that seem to get in the way when it comes to a patient's ability to maintain a healthy smile. The era of "**LASERS IN DENTISTRY**" has only just begun.

Starting a venture in any field will not yield success, without continuously battling for what you want with full determination. This will help you reach the highest heights. As a woman, the journey was never easy. The journey to showcase and shine light to an unused technology in this field was full of tough times and challenge. Nevertheless, I can see with conviction that your focus, determination, and patience are integral to achieving your loftiest goals. For me still feels like day #1... and the journey continues. ■

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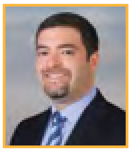
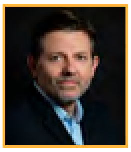


**Dr. Fernando Meza**
USA - Endodontics

**Dr. David Kim**
USA - Perio/Implantology

**Dr. Pilar Martin**
Spain - Dental Dermatology



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