Sudan University of Science and Technology

College of Graduate Studies

Clinical Effects of Photodynamic and Low-Level Laser Therapy as an Adjunct to Scaling and Root Planning of Chronic Periodontitis

التأثيرات السريريه للعلاج الضوئي الديناميكي والعلاج بالليزر منخفض القدرة كعامل مساعد لتقشر ومعالجة جذور دواعم السن المزمن

A Dissertation of Graduation project submitted for partial fulfillment higher diploma in laser Application in Dentistry

By

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March 2022

Dedication

To the soul of my dear father

To my dear beloved mother

To my helpful brother

To my kindly sisters

To all my friends and colleagues, who helped and encouraged me to continue. To all of them, I dedicate this project

Acknowledgement

Firstly I thank ALLAH for giving me strength to complete this study. I would like to express great thanks to my supervisors Dr. Elhadi Mohieldin Awooda for his support and supervision. Also I would like to thank Dr. Ali Abdelrahman for his help and guidance. A special thanks to the staff of Institute of Laser at Sudan University of Science and Technology. My thanks extend to the staff of Hajelsafi Hospital for their unlimited assistance to complete this study. Also I would like to thank all subjects whom participate in the study for their cooperation and patience

Abstract

The aim of this study is to evaluate the clinical effects of PDT, as adjunct to conventional SRP alone in the treatment of chronic periodontitis.

Three patients (2 females and one male) ,with age: ranging from 18–60 years were selected for the study .Thirty site were examined for patient Plaque index (PI),Gingival index (GI), PDs, and The probing pocket depth and CALs were measured using graduated periodontal probe . The subjects were divided in to three group SRP, single episode of PDT using 1% MB solution and LLLT using a a diode laser ・Group II: SRP and single episode of PDT using 1% MB solution as a photosensitizer ・Group III: SRP only.

The obtained results indicated that patients treated with the SRP, single episode of PDT using 1% MB solution and LLLT had less plaque index gingival index and clinical attachment loss when compare d to patients treated with SRP and 1% MB solution as a photosensitizer a and those treated with SRP only (0.001).

Based on the results, it can be concluded that treatment of periodontal pocket with the SRP, single episode of PDT using 1% MB solution and LLLT provides less plaque index gingival index and clinical attachment loss when compare d to patients treated with SRP and single episode of PDT using 1% MB solution as a photosensitizer a and those treated with SRP only.

الخلاصة

الهدف من هذه الدراسة هو تقييم علاج الجيوب اللثوية بمادة المثيلين الازرق بالإضافة الى نظافه اللثة لطريقة العادية مستخدمين تقنية الليزر مقارنة مع العلاج بالطريقة العادية فقط.

تم اختيار ثلاثة متبرعين اثنين اناث و ذكر من الاشخاص الذين تتراوح اعمارهم بين 16- 60 سنه واجري الكشف على ثلاثين موضعا لكل المرضى وتم تقسميهم لثلاثة مجموعات.

المجموعة الاولى عولجوا باستخدام مادة المثيلين الزرقاء وكان تركيزها 1% بالإضافة الي ازالة الترسبات بالطريقة التقليدية واستخدام تقنية الليزر، اما المجموعة الثانية تم علاجهم باستعمال الطريقة التقليدية لإزالة الترسبات بالإضافة لمادة المثيلين الزرقاء وعلاج المجموعة الثالثة بإزالة الترسبات بالطريقة التقليدية. تم قياس مؤشر الترسبات ومؤشر اللثة كما اجري قياس عمق الجيوب اللثوية باستخدام المسبار المدرج لكل المرضى، تم تسجيل المؤشرات قبل بداية العلاج وبعد العلاج بشهر.

اشارت النتائج المكتسبة بان المرضى الذين تم علاجهم بإجراء علاج اللثة التقليدي و باستخدام مادة المثيلين والليزر لديهم مؤشرات لثة وترسبات اقل مقارنة مع المجموعات الاخرى اضافة الى نقص عمق الجيوب اللثوية. بناءا على النتائج نستخلص بأن تقنية الليزر اضافة لعلاج اللثة التقليدي واضافة مادة المثلين الازرق خفض عمق الجيوب اللثوية ونقصان مؤشرات اللثة وترسبات مقارنة مع المجموعات الأخرى .

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Chapter One

Introduction and Literature Review

1.1 **Introduction**

Periodontitis is a multifactorial disease characterized by complex inflammation and disruption of normal homeostatic processes by bacterial species found in sub gingival plaque (1) Severe damage caused by periodontal disease can cause pain, reduced effectiveness of mastication and loss of teeth (2) Pathogens in the oral microbiota that colonize the teeth surfaces enter the periodontal tissues and form subgingival plaque biofilms. In general, the pathogenesis of periodontitis is a complex interaction between microbes, host tissues and individual immune responses (3) which are then modified by various factors, including environment, age and habits, such as smoking (4,)

Lasers have been used in periodontal treatment since the mid-1980s. Light Amplification of Stimulated Emission by Radiation (Laser) creates a collimated beam, with a single wavelength and colour. Photon rays that reach biological tissues can be reflected, dispersed, absorbed or transmitted to surrounding tissues. Lasers can cause excellent tissue ablation, bactericidal and detoxifying properties that leave little or no smear layer so that can stimulate surrounding cells to improve healing [5].

Dental lasers are classified into several categories based on wavelength, with most used for dental applications being in the range 500–10,000 nm. Several media exist to generate this energy, ranging from semiconductors to crystals, and each creates a particular wavelength with a unique affinity for a respective target (chromophore) based on absorption coefficients and depth of penetration [6].

The goal of periodontal treatment is to remove the etiology, halt the inflammatory process, and restore connective tissue attachment and alveolar bone loss. Regeneration and new attachment gain has been technique-sensitive using guided tissue regeneration procedure [1,2].

The photonic energy from Diode & Nd:YAG lasers is in the neon-infrared spectrum (approx.. 800-1100nm) and is selectively absorbed in areas of inflammation by blood components and tissue pigments. A non-contact mode may be employed when attempting any haemostasis.

For initial periodontal therapy, these lasers are used for inactivation of bacteria and removal of inflamed soft-tissue from periodontal pocket/ around the implant sulcus, for achieving hemostasis in acutely inflamed tissue. These procedures employ relatively low average power, which are usually below than that used for surgery.

In general, Nd:YAG laser must be used with caution, and attention must be given to the irradiation parameters and to the laser beam placement These employ photonic energy in far - infrared spectrum

1.2 Objectives

1.2.1 General Objective

To evaluate the clinical effects of PDT, as adjunct to conventional SRP alone in the treatment of chronic periodontitis

1.2.2 Specific objective

1. To evalute the effect of scaling and root planning in treatment of chronic periodontitis

2. To evaluate the effect of scaling and root planning with PDT in treatment of chronic periodontitis

3.To compare the effect of SRP alone with PDT and laser

1.3 Statement of the Problem

Periodontitis may cause tooth loss and occlusion problem gingival recession aesthetic problem so the use of diode laser in treatment of periodontitis reduce the effect of periodontal distraction

1.4 **Literature Review**

Photodynamic therapy (PDT) has introduced in recent years as a new noninvasive therapeutic modality for the treatment of infections caused by bacteria, fungi, and viruses.[6] This therapy is defined as an oxygen‐dependent photochemical reaction that occurs on light‐mediated activation of a photosensitizing compound that leads to the generation of cytotoxic reactive oxygen species, predominantly singlet oxygen.[7] This therapy can be applied topically to a periodontal pocket, hence avoiding overdoses (8)

Harveen S. conducted study in India 2020 to evaluate the efficacy of photodynamic therapy (PDT) and laser therapy as an adjunct to scaling and root planning in the treatment of periodontal pockets. **:** Thirty sites in ten individuals with probing pocket depth ≥ 5 mm were randomly divided into three groups, using 940 nm diode laser at 5.0 watts with 300 micrometer fibreoptic cable in a pulsed mode for 30 seconds. In Group B sites, periodontal pockets were filled with 1% Methylene Blue solution was applied deep into the pocket, kept for 3 minutes and then using 940 nm diode laser at 5.0 watts with 300 micrometer fibreoptic cable in a pulsed mode for 30 second, dye molecules were activated. Group A (sites treated with scaling and root planning followed by laser therapy), Group B (sites treated with scaling and root planning followed by photodynamic therapy) and control was set as Group C . Group A and Group B sites showed statistically significant improvement (≤ 0.005) in probing pocket depth, relative attachment level, plaque index, gingival index and sulcus bleeding index, whereas, Group C showed statistically significant improvement in plaque index and gingival index only.(9)

Moreira *et al*., 2015 concluded that The application of four sessions of aPDT, adjunctive to SRP, promotes additional clinical, microbiologic, and immunologic benefits in the treatment of deep periodontal treatment (10)

Pulikkotil et al.in 2016 conducted studies to assess PI GI .PPD and CAL using scaling and root planning .laser 628 nm Single application of methylene blue. Follow-up time: 7 days, 1 and 3months .Scaling and root planning with PDTand laser lead to to significant improvement of clinical parameters investigated, after 1 and 3 months (11)

Thirty four patients their aged 43.12 ± 8.2 were examined to evaluate bleeding on probing; depth of pocket; level of clinical attachment ,They treated with methylene blue Diode laser (660 nm) single application .Follow-up time: 2, 3 and 6 months .the results of these study revealed that scaling and root planning combined with a PDT led to significant improvement of clinical parameters investigated (12)

Segarra et al. (2017)conducted study among 60 subjects a ged 55 ± 2 years old to assess Plaque index; probing depth; gingival recession, clinical level ; bleeding on probing using methylene blue 0.005% and: diode (670 nm) .Follow-up time: 5, 13 and 25 week . .there is significant improvement in all parameters (13)

In a single‐centered randomized and controlled clinical trial, 24 patients (15 males and 9 females) with untreated chronic periodontitis were randomly assigned in a split‐mouth design into three treatment groups which included Group I: SRP only,Group II: SRP and PDT (1% methylene blue [MB] solution), and Group III: SRP, PDT, and LLLT. Clinical parameters such as plaque index, gingival index, modified sulcular bleeding index, probing depth (PD), and clinical attachment level (CAL) Within each group, significant improvements ($P < 0.001$) were found for all variables in 6‐month follow‐up

compared with baseline. The improvement in clinical parameters was significantly greater in Group III compared to Group I and Group II(14)

Laser concept

LASER is an acronym for 'Light Amplification by the Stimulated Emission of Radiation'. Maiman generated the first laser beam by using a ruby rod. In 1961, the first gas and continuously operating laser was described by Javan et al. he first laser was introduced into the fields of medicine and dentistry during the 1960s by Goldman et al, but the thermal damage was too great to consider this laser as a clinical instrument. Patel produced the first laser with CO2 in 1964.Stern and Sognnaes in 1964 began looking at the possible uses of the ruby laser in dentistry. In Romania, the first laser with CO2 and Nd - YAG was produced in 1968. A pioneer in the area of clinical periodontal and oral surgery is Pick, who, along with his colleagues in 1985, reported on laser gingivectomy (Todea, 2004).

Properties of Laser

Light is a form of electromagnetic energy that exists as a particle, and travels in waves, at a constant velocity. The basic unit of this radiant energy is called a photon; the wave of photons travels at the speed of light and it can be defined by two basic properties. The first is amplitude, which is defined as the vertical height of the wave oscillation from the zero axis to its peak. This correlates with the amount of energy in the wave: the larger the amplitude, the greater the amount of energy.

The second property of a wave is wavelength, which is the horizontal distance between any two corresponding points on the wave. These two parameters are very important, both with respect to how the laser light is delivered to the surgical site and to how it reacts with the tissue

As the waves travel, they oscillate several times per second, and this is termed frequency'. Frequency is inversely proportional to the wavelength: the shorter the wavelength, the higher the frequency and vice versa (Edwards and Reiman,2008), as illustrated in figure

A laser differs from a conventional light source in four aspects. First, the laser emits radiation in a highly unidirectional (collimation) beam, secondly, the radiation is extremely pure in colour (monochromaticity) , thirdly high degree of coherence , i.e, the degree of correlation between the phase at two different pointson beam of light.

The four characteristic of laser radiation is that the intensity can greatly exceed that of conventional light , particularly in pulsed laser (Nityanand and Richa, 2011). A laser is a device that transforms the light of various frequencies into a chromatic radiation in the visible, infrared, and ultraviolet regions, with all the waves in the phase being capable of mobilizing immense heat and power when they are focused at a close range (Olivi and Genovese, 2011). It emits light through a process called stimulated emission, which features the collimated (parallel) and coherent (temporally and spatially constant) electromagnetic radiation of a single wavelength

Laser Types

The laser systems which have been developed to date have been classified according to the active medium that is stimulated to emit the photon energy intosolid state, gas, liquid or dye and semiconductor lasers

Solid state lasers are high density lasing material in form of crystal of glass likematerial dopped with chromium, Neodymium, sapphire etc. Solid-statearepumped with discharge lamps or diode laser. These include ;Ruby , Nd-YAG,Alexandrite, Er-YAG.

Gas Laser**:** These types of lasers involve gas as a medium when excited by electrical discharge produce light. The gas laser can be characterized as atomic,ionic or molecular depending on the laser material used. Helium-neon, Argon and CO2 lasers are the most common gas lasers having output in visible, UV and far infrared lasers.

Liquid or Dye Lasers**:** These lasers have active medium as colored compoundscarried by a solvent. The common materials used in these lasers are copper chromium, dyes, metallic salts. The major advantage of these, that can be tuned to broad range of wavelengths. They are useful in isotope separation, measurement and integrated circuit manufacturing.

Semiconductor Laser**:** These lasers are sometimes called as diode lasers. The gain medium is made from a direct band gap semiconductor material based on eithergallium arsenide (GaAs) or InP substrates. Unlike other lasers, these devices generally small , use low power and extremely reliable. Lasers may also be classified according to their mode of operation into continuous and pulsed lasers. Continuous wave (CW) **:** These lasers operate with a stable constant poweremitting steady beam of light. A continuous wave lasers usually have the light energy expressed in watts.

Photochemical (photodynamic) Reactions

Fluence rates below the hyperthermia threshold can be used for Photodynamic therapy (PDT), a two-step modality in which the delivery of a light activated and lesion-localizing photosensitizer is followed by a low, non-thermal dose of light irradiation. Photochemical reactions of biological relevance are dependent on generation of reactive oxygen species

Bio stimulation and wound healing

Lower CW light fluence rates and doses than those used in PDT are used. Laser penetration into tissues is a few tenths of a millimetre, and the treatments are often termed ‘low laser level therapies’,

LLLTs, also known as photobiomodulation, cold laser therapy and laser biostimulation. The following applications have been proposed: tumour treatment, treatment of tinnitus, epilepsy, pain, thrombosis, reduction of the recovery time after traumas or surgery, treatment of hyperlipidemia and strengthening of the immune system (Navratil and Kymplova, 2002).

The chromophores for possible biostimulative effects are unknown, and so are the cell reaction

Chapter Two

Material and Methods

1.2 Study design

Randomized and controlled clinical trial

2.2 Study population

Patients attend at outpatient clinic in Hjelsafi hospital

2.3 Study duration

January to February 2022

2.4 Study area

Sudan University of Science and Technology (Institute of laser)

2.5 Sample size

Three patients (2 females and one male) ,thirty site were examined for patient

2.6 Inclusion criteria

Age: 18–60 years

At least twenty teeth present

At least one site in each quadrant of the mouth having

Probing depth ≥5 mm

• Signed informed consent

2.7 Exclusion criteria

Pregnant or lactating females

Smoker and/or alcohol consumption subjects

Use of antibiotics within 6 months prior to the study

Active periodontal treatment within last 6 months

Subjects systemic disease

Procedure

Screening and examinations

The following clinical parameters Plaque index (PI), Gingival index (GI), PDs, and the probing pocket depth and CALs were measured using graduated periodontal probe. Measurements were done at selected sites. All measurements were performed by one experienced periodontal examiner, allowing an intra‑experimental comparison of the values. Percentage agreement with another examiner within 1 mm was >96%. The probing angulation was standardized using an acrylic stent, on which a groove was marked representing the site chosen for the treatment based on the chart measurements earlier made on the patient. The reading was recorded to the nearest millimeter. Clinical attachment level (CAL) were recorded The subjects were divided in to three group.

Group I: SRP, single episode of PDT using 1% MB solution and LLLT using a a diode laser

• Group II: SRP and 1% MB solution as a photosensitizer

• Group III: SRP only

Periodontal and adjunctive laser treatments

All patients received routine oral hygiene instructions and one‐stage full‐mouth conventional SRP employing both hand instruments and a piezoelectric ultrasonic hand piece

Group II and Group III underwent a single episode of PDT.

The periodontal pockets were filled with a 1% MB solution as photosensitizer employing a blunt cannula starting from the bottom of the pocket to achieve both a complete filling of the pocket and coating of the root surface, which was left for 3 min before any excess was gently rinsed away. The remaining photosensitizer was activated for 30 s to 45 s per site The diode laser was operated at a peak power of 1.0 W, with a pulse length of 200 μs , using a 400 μm fiber‐optic tip and a wavelength of 980 nm. The tip was initiated and introduced into the pocket with a smooth stroking action, starting coronally, and working toward the bottom of the pocket. Oral hygiene instructions were reinforced for all groups.

2.8 Ethical considerations:

1. Approval of the institute of laser.

2. Informed consent are obtained from each patient.

3. Ethical approval from the ethical committee of the Ministry of Health–Kh

Chapter Three

Results

Table (3.1) Shows plaque index of different groups at base line and after one month

`Subject	Baseline and after 1 month	Mean	P .Value
Group I	Base line	2.16 +0. 22	0.005
	1month	0.22 +0.14	
Group II	Base line	2..14+0.28	0.005
	1month	0.35 +0.20	
Group III	Base line	1.88 + 0.44	0.005
	1month	1.20 +0.50	

Table (3.2) Shows mean of gingival index of different groups at base line and after one month

Gingival index			
Subjects group	**Base line**	**Mean**	**P .Value**
Group I	Base line	2.35 +0.28	0.005
	1month	0.28 +26	
Group II	Base line	2..23 +0.47	0.005
	1month	0,32 +0.36	
Group III	Base line	2.32 + 041	0.001
	1month	1.23+0.4	

Table (3.3) Shows plaque index of different groups at base line and after one month

Pocket depth			
Subjects group	**Base line**	**Mean**	**P .Value**
Group I	Base line	6..10+1.10	0.002
	1month	0.28 +26	
Group II	Base line	5.50+0.47	0.005
	1month	3,32 +0.36	
Group III	Base line	6.32 + 071	0.001
	1month	5.23+0.43	

Table (3.4) Mean of attachment loss in different three groups

Clinical attachment level			
Subject	**Base line**	**Mean**	**P .Value**
Group I	Base line	9,70+ 17	0.001
	1month	6.50+1.80	
Group II	Base line	9.30+1.33	0.001
	1month	6.80 +1.55	
Group III	Base line	9.60+1.23	0.001
	1month	8.20+1.26	

Chapter Four

Discussion Recommendation and conclusion

4.1 Discussion

The clinical management of patients with periodontal disease can be based on criteria given by both bacterial and clinical parameters that can be compared at different time intervals. In the present study, laser therapy as well as photodynamic therapy (laser + photosensitizer) has been used as an adjunct to scaling and root planning in the treatment of periodontal pockets.

There have been recent reviews suggesting photodynamic therapy has limited effects on clinical parameter which can be dis agree to result of present study. The overall improvement in clinical parameters. Probing pocket depth, clinical attachment level, gingival index, and plaque index is far better when compared with the previous study.

Moreira *et al*., 2015 concluded that The application of a PDT, as adjunctive to SRP, promotes additional clinical, microbiologic, and immunologic benefits in the treatment of deep periodontal treatment this finding agree with r results of present study (10)

Pulikkotil et al.counducted study to assess GI,PI and CAL and found significant improvement in all parameter this finding is in accordance to results of present study (11)

Harveen S. conducted study in India 2020 to evaluate the efficacy of photodynamic therapy (PDT) and laser therapy as an adjunct to scaling and root planning in the treatment of periodontal pockets. And the results revealed statistically significant improvement (≤ 0.005) in probing pocket depth, relative attachment level, plaque index, gingival index and sulcus bleeding index, However this finding similar to results of present study (9)

In the present study the results of all clinical parameter is statistically significant (≤ 0.005) which in accordance to study carried out in 2017 by Theodora (12)

Suryakanth M examined 24 patients with untreated chronic periodontitis were randomly assigned to evaluate the effect of scaling root planning and photo dynamic therapy on gingival index , plaque index and pocket depth , significant improvements ($P < 0.001$) were found for all variables (14).and this finding is agree with results of present study

4.2 Conclusion

Both the laser and photodynamic therapy can be a beneficial adjunct to scaling and root planning in the treatment of periodontal pockets without the use of antibiotics thereby reducing the antibiotic consumption and its potential side effects.

Used of aPDT as an adjunct to nonsurgical periodontal treatment seems to be therapeutically useful.

Further studies of aPDT are needed for establishing this as a beneficial adjunct treatment for periodontitit.

4.3 Recommendations

More longitudinal studies with larger sample size are required to confirm the exact efficacy of diode laser over the conventional treatment technique for treatment of chronic periodontitis.

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