Sudan University of Science and Technology

Graduation College

كلية الدراسات العليا

TO EVALUATE THE EFFECT OF DIODE LASER AS AN ADJUNCT TO SCALING AND ROOT PLANING IN TREATING PERIODONTITIS STAGE III

لتقييم تأثير الليزر الثنائي كعامل مساعد في تقليح وتنعيم الجذور في علاج المرحلة الثالثة من التهاب الانسجه المحيطه بالسنة

A Dissertation Submitted in Partial Fulfilment for the Requirements for the Degree of Diploma in Laser Application in Dentistry

By

Hussein AbdelRahman Murtada AbdelRahman

Supervisors

Assoc.prof. Amna Algarrai

Assoc.prof. Sohad Alwakeel

2022

DEDICATION

To my Father:

For his uncompromising moral principles that guided his life and ours

To my Mother:

For guiding her children into scholarly pursuit

To my Brother:

For his love and devotion to his family

To my Family:

For making all this worthwhile

ACKNOWLEDGMENT

First of all, I must thank Almighty Allah for enabling me to conduct this study.

I would like to express my sincere gratitude to my supervisor Dr Amna El Garay, for introducing me to the world of research in laser application. Her guidance helped me in all the research and writing of this thesis. Thanks for your continuous support. I am so lucky to be under your supervision.

Sincere appreciation to everyone who accepted participating in this study could not have been without you.

Thanks to everyone who was involved in the validation of this thesis. Your support and encouragement made things go much smoother.

ABBREVIATIONS

PD	Pocket depth
BOP	Bleeding on probing
CAL	Clinical attachment loss
PI	Plaque index
GI	Gingival index
PG	Prostaglandin
COPD	Chronic obstructive pulmonary disease

ABSTRACT

BACKGROUND:

Periodontal disease is a chronic inflammatory multifactorial disease with microbial plaque and calculus being the prime factors. As the dental plaque biofilm accumulates, different bacterial species may colonise and develop into a biofilm. The subgingival plaque comprises of a complex microbiota consisting mainly of gram-negative anaerobic bacteria. The microorganisms most often detected at high levels include A. actiniomycetemcomitans, P. gingivalis, T. forsythia, and T. denticola.

The goals of periodontal treatment include the arrest and control of infection, removal of plaque and calculus, reduction in the amount of bioburden within the pocket, and providing an environment where the tissue can return to health.

The initial phase of treatment is SRP, which is considered as the gold standard. However, some microorganisms remain on the root surface even after root planing and scaling procedures.

LASER" is an acronym for "Light Amplification by Stimulated Emission of Radiation". The laser properties of monochromaticity, directionality and coherence make lasers unique and suitable for applications in the medical and dental fields

The Diode laser does not interact with dental hard tissues making it convenient for soft tissue operations, cutting and coagulation of gingiva, soft tissue curettage, or sulcular debridement

AIMS AND OBJECTIVES

This study aims to evaluate the effect of diode laser as an adjunct to SRP in treating periodontitis stage III based on periodontal parameters.

MATERIALS AND METHOD:

A randomised clinical trial with a split-mouth design was conducted. The clinical parameters of pocket depth plaque index, gingival index and clinical attachment loss level are measured at the baseline

Half of the mouth (right side) was treated with scaling and root planning alone, and the other half (left side) was treated with scaling and root planning and laser therapy and; measure the clinical parameters after one month

RESULTS:

The mean plaque index on the right side at baseline was 1.25and after one month was 0.16. The mean gingival index on the right side at baseline was 1.16, and after one month was 0.3. The Mean pocket depth on the right side at baseline was 1.6 and after one month was 1.4. Clinical attachment loss on the right side at baseline was 2.9 mm, and after one month was 1.9 mm. The mean plaque index on the side at baseline was 1.05 and, after one month, was 0.05. The mean gingival index on the left side at baseline was 1.3, and after one month was 0.08. Mean pocket depth on the left side at baseline was 2.0 mm and after one month was 0.5 mm Clinical attachment loss on the left side at baseline was 2.7 mm and after one month was 1.01 mm.

CONCLUSIONS:

There is a reduction on both sides in all parameters, but on the side laser, more than the scaling and root planing only

KEYWORDS:

Lasers, Periodontitis,

المستخلص

مقدمة

أمراض اللثة هي امرض التهابية مزمنة متعددة العوامل مع وجود البلاك الجرثومي والقلح من العوامل الرئيسية. عندما تتراكم طبقة البلاك الرقيقة علي الأسنان ، قد تستعمر أنواع بكتيرية مختلفة وتتطور إلى غشاء حيوي. تشمل أهداف علاج اللثة السيطرة على العدوى ومكافحتها ، وإزالة البلاك والقلح ، وتقليل كمية العبء الحيوي داخل الجيب اللثوي، وتوفير بيئة يمكن فيها للأنسجة أن تعود إلى حالتها الصحية

المرحلة الأولى من العلاج هي التحجيم وكشط الجذر ، والتي تعتبر المعيار الذهبي. ومع ذلك ، تبقى بعض الكائنات الحية الدقيقة على سطح الجذر حتى بعد تحجيم كشط الجذر

لا يتفاعل ليزر الدايود مع أنسجة الأسنان الصلبة ، مما يجعله مناسبًا لعمليات الأنسجة الرخوة ، وقطع وتجلط اللثة ، وكشط الأنسجة الرخوة

الاهداف

تهدف هذه الدراسة إلى تقييم تأثير ليزر الدايود كعامل مساعد لـ SRP **في علاج التهاب دواعم السن من المرحلة الثالثة أو الرابعة بناءً على معايير اللثة.**

المواد والطرق

تم تنفيذ تصميم الفم الانقسام في يعالج نصف الفم (الجانب الأيمن) بالتقشير وتخطيط الجذور وحده والنصف الآخر (الجانب الأيسر) يعالج بالتقشير وتخطيط الجذور والعلاج بالليزر وقياس المعايير السريرية بعد شهر واحد

النتائج:

كان متوسط PI **على الجانب الأيمن عند خط الأساس** 1.25 **وبعد شهر واحد كان** 0.16

كان متوسط GI **على الجانب الأيمن عند خط الأساس** 1.16 **وبعد شهر واحد كان** 0.3

كان متوسط PD **على الجانب الأيمن عند خط الأساس** 1.6 **وبعد شهر واحد كان** 1.4

كانت متوسط CAL **على الجانب الأيمن عند خط الأساس** 2.9 **وبعد شهر واحد كانت** 1.9

كان متوسط PI**على الجانب عند خط الأساس** 1.05 **وبعد شهر واحد كان** 0.05

كان متوسط GI **على الجانب الأيسر عند خط الأساس** 1.3 **وبعد شهر واحد كان** 0.08

كان متوسط PD **على الجانب الأيسر عند خط الأساس** 2.0 **وبعد شهر واحد كان** 0.5

كان متوسط CAL **على الجانب الأيسر عند خط الأساس** 2.7 **وبعد شهر واحد كان** 1.01

الخلاصة

هناك انخفاض في كلا الجانبين في جميع المتغيرات السريرية ولكن على الجانب بالليزر أكثر من التحجيم وكشط الجذر فقط

TABLE CONTENTS

LIST OF FIGURES

CHAPTER ONE

1. INTRODUCTION AND LITERATURE REVIEW:

1.1. BACKGROUND

Periodontal disease is a chronic inflammatory multifactorial disease with microbial plaque and calculus being the prime factors. A dental plaque infection is defined as "an infectious disease resulting in inflammation within the supporting tissues of the teeth, progressive attachment loss, and bone loss" (Lim, G., Janu, U., Chiou, L-L., Gandhi, K. K., Palomo, L., John, 2020).

Approximately 40% of adults suffer from periodontitis worldwide. According to the Global Burden of Disease 2015, the prevalence of severe periodontitis was estimated at 7.4% (Jawad *et al.*, 2011).

When oral hygiene is neglected, oral bacteria form a plaque biofilm, resistant to chemicals and immune cells. Without mechanical debridement, the plaque biofilm matures and causes gingivitis within a few days (Matilainen *et al.*, 2014). Gingivitis represents a chronic but reversible inflammation and can be treated by proper plaque control. Gingivitis usually does not extend to irreversible periodontitis for months or years (Matilainen *et al.*, 2014). However, periodontitis is an irreversible chronic destructive inflammation of the periodontium (Lim *et al.*, 2020).

As the dental plaque biofilm accumulates, different bacterial species may colonise and develop into a biofilm. The subgingival plaque comprises of a complex microbiota consisting mainly of gram-negative anaerobic bacteria. The microorganisms most often detected at high levels include A. actiniomycetemcomitans, P. gingivalis, T. forsythia, and T. denticola (Nada Tawfig Hashim, 2018). The resultant destruction results from the different immunoinflammatory pathways that affect the bone and connective tissues (Sanz *et al.*, 2020a)

The latest classification of periodontal diseases by the American Academy of Periodontology (AAP) and the European Federation of Periodontology (EFP) has categorised periodontitis into three sub-types: "periodontitis", necrotising periodontitis, and periodontitis as a manifestation of systemic disease (G. Caton *et al.*, 2018).

The goals of periodontal treatment include the arrest and control of infection, removal of plaque and calculus, reduction in the amount of bioburden within the pocket, and providing an environment where the tissue can return to health. The treatment for this disease entity is staged and multifaceted. The initial phase of treatment is SRP, which is considered as the gold standard. However, some microorganisms remain on the root surface even after root planing and scaling procedures. Deep periodontal pocket, furcation involvement, various anatomic factors, etc., make it difficult to eliminate bacterial toxins by non-surgical therapy. These limitations of conventional mechanical therapy lead to other adjunct modalities for treating chronic periodontitis (Cobb, 2006).

"LASER" is an acronym for "Light Amplification by Stimulated Emission of Radiation". The laser properties of monochromaticity, directionality and coherence make lasers unique and suitable for applications in the medical and dental fields (Gursel, 2018).

In 1917, Albert Einstein laid the foundation for the invention of the laser and its predecessor, 'the Maser,' by theorising that photoelectric amplification could emit a single frequency or stimulated emission.

The introduction of lasers in dentistry, in the 1960s, by Miaman led to continuous research on the various applications of lasers in dental practice. Theodore Maiman, at the Hughes Research Laboratories in Malibu, CA, built the first functioning laser using a mixture of helium and neon. In 1961, a laser was developed from crystals of yttrium-aluminum-garnet treated with 1-3% neodymium (Nd: YAG). (Verma *et al.*, 2012)

The laser types for non-surgical periodontal therapy include the Diode, Nd:YAG, CO2, and Erbium lasers. The Diode laser does not interact with dental hard tissues making it convenient for soft tissue operations, cutting and coagulation of gingiva, soft tissue curettage, or sulcular debridement (Cobb, 2006). In addition, Diode Laser combined with scaling and root planing (SRP) has significantly reduced inflammation and decreased bacterial loads (Crispino *et al.*, 2015).

The bactericidal and detoxifying effect of laser treatment is beneficial in periodontal therapy. However, the various studies in the literature on lasers as an adjunct to SRP show contradictory results in clinical outcomes. Therefore, this study aimed to determine the effect of diode laser in treating periodontitis stage III or IV as an adjunct to SRP.

1.2. AIMS AND OBJECTIVES

This study aims to evaluate the effect of diode laser as an adjunct to SRP in treating periodontitis stage III based on periodontal parameters.

1.2.1. Research Hypothesis:

Does diode laser have an adjunctive effect along with SRP in treating periodontitis?

1.2.2. Objectives:

1.2.2.1 General Objectives:

To determine the effect of SRP, SRP with Laser on clinical parameters.

1.2.2.2 Specific Objectives:

1. Comparison of SRP, SRP with Laser on clinical parameters.

1.3. THEORETICAL BACKGROUND AND LITERATURE REVIEW

1.3.1. Historical Development

Approximately 40% of adults suffer from periodontitis worldwide. According to the Global Burden of Disease 2015, the prevalence of severe periodontitis was estimated at 7.4% (Jawad *et al.*, 2011).

When oral hygiene is neglected, oral bacteria form a plaque biofilm, resistant to chemicals and immune cells. Without mechanical debridement, the plaque biofilm matures and causes gingivitis within a few days (Matilainen *et al.*, 2014). Gingivitis represents a chronic but reversible inflammation and can be treated by proper plaque control. Gingivitis usually does not extend to irreversible periodontitis for months or years (Matilainen *et al.*, 2014). However, periodontitis is an irreversible chronic destructive inflammation of the periodontium (Lim *et al.*, 2020).

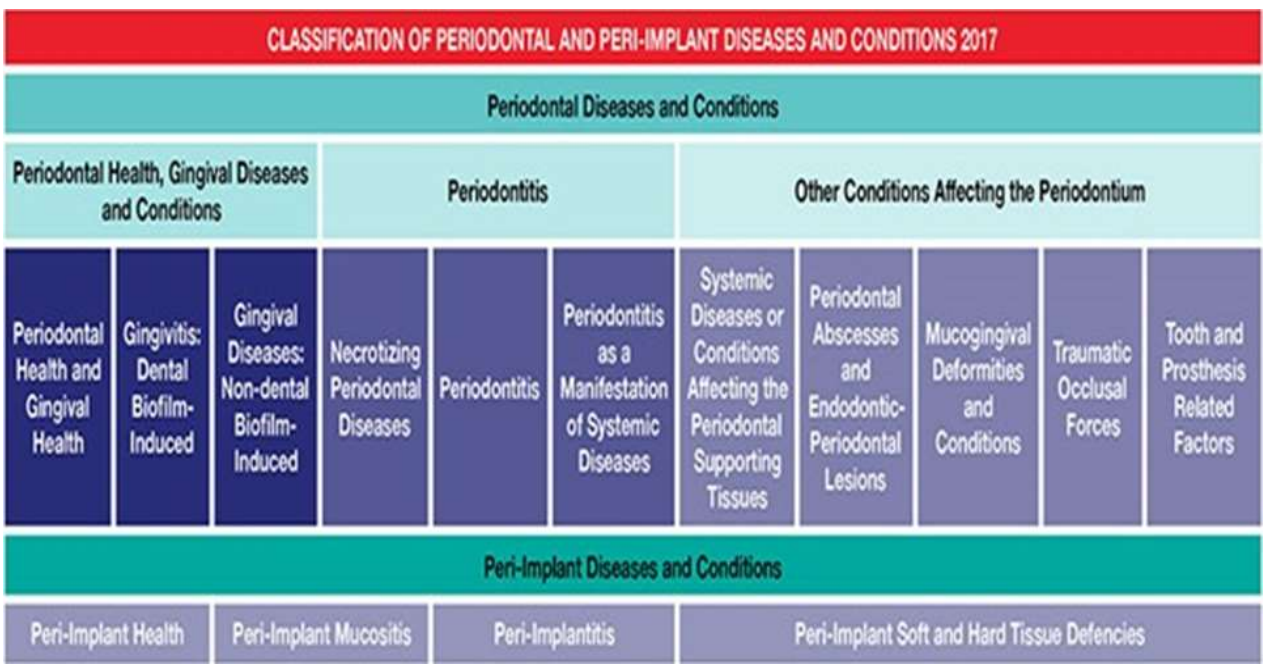
Over the years, numerous classification systems have been developed to organise the various disease entities affecting the periodontium. Since the 1999 world workshop classification, important new information has emerged from basic science investigations and prospective studies evaluating environmental and systemic risk factors. As a result, the 2017 Classification of Periodontal and Peri-implant Diseases and Conditions was adopted. In addition, periodontitis's chronic and aggressive entities have been reclassified as one category due to insufficient evidence to consider aggressive and chronic periodontitis as two distinct pathophysiological diseases (Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, 2016).

Periodontitis is characterised by microbially-associated, host-mediated inflammation that results in loss of periodontal attachment, which is detected as clinical attachment loss (CAL) by circumferential assessment of the erupted dentition with a standardised periodontal probe concerning the cementoenamel junction (CEJ) (Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, 2016).

Table 1: 1999 World Workshop Classification of the Periodontal diseases

Type	1999 Classification of periodontal disorders
I	Gingival diseases
II	Chronic periodontitis
III	Aggressive periodontitis
IV	Periodontitis as a manifestation of systemic disease
V	Necrotizing periodontal diseases
VI	Periodontal abscess
VII	Periodontitis in combination with endodontic lesions
VIII	Developmental or inherited conditions

Table 2: The 2017 World Workshop classification of periodontal diseases and conditions (11)



In revising the classification, the workshop agreed on a classification framework for periodontitis further characterised based on a multidimensional staging and grading system that could be adapted over time as new evidence emerges (Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, 2016).

The European Federation of Periodontology (EFP), the American Academy of Periodontology (AAP), and various international associations of periodontology met at the end of 2017 and agreed on a new classification of periodontal and peri-implant diseases (G. Caton *et al.*, 2018). Accordingly, a new classification was set, as illustrated (Table 2).

According to the above classification, Periodontitis is now classified into three types: necrotising periodontitis, periodontitis as a manifestation of systemic disease, and the forms of the disease previously defined as "chronic" or "aggressive", now classified under a single category, "periodontitis" (Sanz *et al.*, 2020b).

Periodontitis, by definition, is: "a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterised by the progressive destruction of the tooth-supporting apparatus" (Sanz *et al.*, 2020b). Evident factors characterise it: Loss of periodontal-tissue support, manifested through clinical attachment loss (CAL), alveolar bone loss assessed by radiographs, probing periodontal pockets, and gingival bleeding (Sanz *et al.*, 2020b).

Experimental studies concluded that bacterial plaque is the primary factor initiating periodontitis; bacteria and immunoinflammatory mechanisms are implicated in this complex disease. Pathogenesis of periodontitis involves bacterial activation of immunoinflammatory mechanisms that adversely affect bone and connective tissue remodelling (Kornman, 2008).

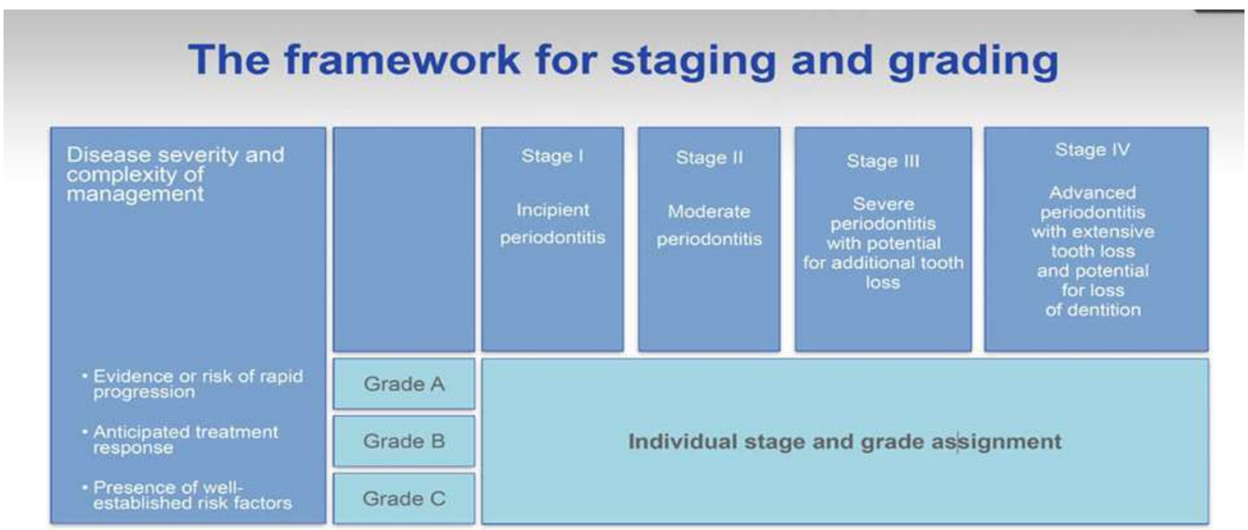
The first complex associated with the disease is called the "orange complex," which consists of gram-negative, anaerobic species such as *Prevotella intermedia* and *Fusobacterium nucleatum* (4,5). As the disease worsens, the microbiota changes to the "red complex," consisting of the periodontal pathogens *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola* (Socransky, Sigmund S., Haffajee, 2005).

Host response is also now recognised as a major contributor to periodontal tissue damage, as the role of the immune cells is becoming clearer in the degree of destruction (Socransky, Sigmund S., Haffajee, 2005). In addition, some evidence supports that disease influences multiple immunoinflammatory responses, making changes more likely for some patients than others and may influence the severity of disease for such individuals (Sanz *et al.*, 2020b).

Staging depends on the severity of the disease at presentation and the complexity of disease management. At the same time, grading provides information about the biological features of the disease and the rate of progression (Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, 2016).

Periodontitis may progress at different rates in individuals, respond less predictably to treatment in some patients, and may or may not influence general health or systemic disease (N.T. Hashim, 2018). For example, risk factors such as cigarette smoking and the metabolic rate of diabetes affect the rate of progression of periodontitis and, consequently, may increase the conversion from one stage to the next. In addition, emerging risk factors like obesity, specific genetic factors, physical activity, or nutrition may one day contribute to the assessment. Therefore, a flexible approach must be devised to ensure that the case-definition system will adapt to the emerging evidence (Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, 2016).

Table 3: The 2017 World Workshop classification of periodontal diseases and conditions according to the staging and grading system (Verma *et al.*, 2012)**.**



2. CHAPTER TWO: BASIC CONCEPT OF LASERS

In 1917, Einstein laid the foundation for the laser when he introduced the concept of stimulated emission, where a photon interacts with an excited molecule or atom and causes the emission of a second photon having the same frequency, phase, polarisation and direction. The acronym LASER stands for "Light Amplification by Stimulated Emission of Radiation (Andersen, 2020).

Theodore Maiman was the first to demonstrate the earliest practical Laser in 1960 after the reports by several scientists, including the first theoretical description of Ladenburg on stimulated emission and negative absorption in 1928 and its experimental demonstration by Lamb and Rutherford in 1947 and the suggestion of Alfred Kastler on optical pumping in 1950 and its demonstration by Brossel, Kastler, and Winter two years later (Andersen, 2020).

Maiman's first Laser was based on the optical pumping of synthetic ruby crystal using a flash lamp that generated pulsed red laser radiation at 694 nm. Iranian scientists Javan and Bennett made the first gas laser using a mixture of He and Ne gases in the ratio of 1: 10 in 1960, while Hall demonstrated the first diode laser made of gallium arsenide (GaAs) in 1962, which emitted radiation at 850 nm. Later in the same year, Holonyak developed the first semiconductor visible-light-emitting laser (Andersen, 2020).

"LASER" is an acronym for "light amplification by stimulated emission of radiation." It refers to a device that emits light that is spatially coherent and collimated; a laser beam can remain narrow over a long distance, and it can be tightly focused (Maiman, 1960)

A laser beam is created from a substance known as the active medium, is placed between a pair of optically parallel and highly reflective mirrors with one of them partially transmitting, and an energy source to pump the active medium, which may be a solid, liquid, or gas. They have the property to amplify the light wave amplitude passing through it by stimulated emission. The pumping source may be electrical or optical. The gain medium used between a pair of mirrors is placed so that light oscillating between the mirrors passes every time through the gain medium and, after attaining considerable amplification, emits through the transmitting mirror (Singh SC, Zeng H, Guo C, 2012).

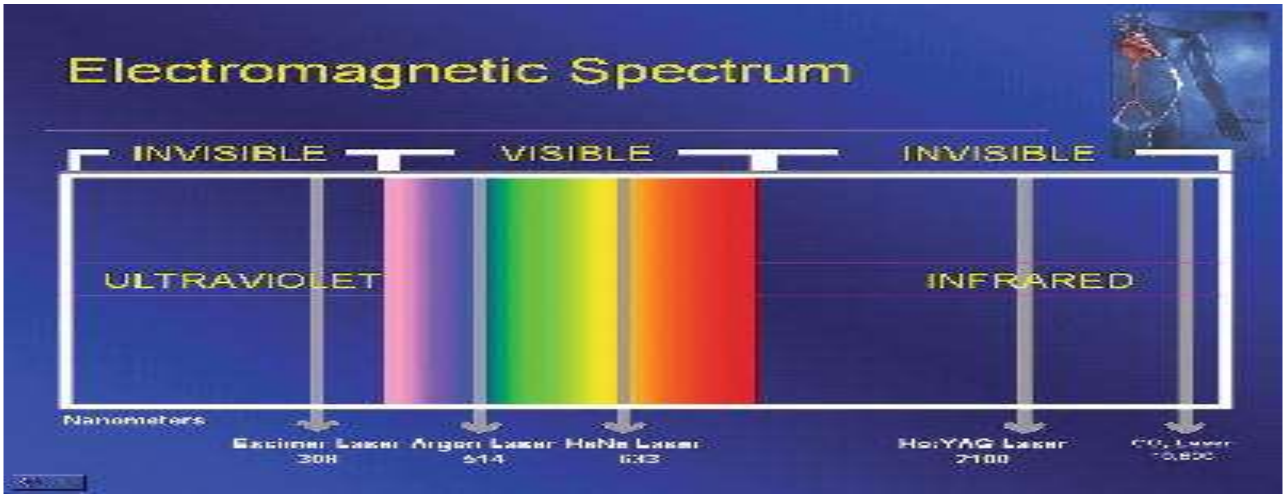


Figure 1: Dental laser wave lengths on the electromagnetic spectrum:

2.1.1. Uses Of Lasers in Dentistry:(Jawad *et al.*, 2011)

The various uses of Laser in dentistry are as follows;

- Gingivectomy/gingivoplasty
- Excision of tumours/lesions
- Incision/excision biopsies
- Frenectomy/Frenotomy
- Removal of hyperplastic/granulation tissue
- Second-stage recovery of implants,
- Treatment of periodontal disease
- Arthroscopic temporomandibular joint surgery
- Caries diagnosis and removal
- Curing of composites
- Activation of tooth-bleaching solutions and etc.,

2.1.1.1 Properties of Lasers:

The light produced from the lasers has several valuable characteristics not shown by light obtained from other conventional light sources, making them suitable for various scientific and technological applications. For example, lasers demonstrate the monochromaticity, directionality, and coherence of laser light, making them important for various materials processing and characterisation applications. Monochromaticity means it generates a beam of a single colour, which is invisible if its wave length is outside of the visible part of the spectrum. On the other hand, coherency means they are identical in physical size and shape, which signifies that the amplitude and frequency of all the waves of photons are identical, which results in the production of a specific form of focused electromagnetic energy (Ivanova *et al.*, 2016).

2.1.1.2 Classification of Lasers: (Verma *et al.*, 2012)

Lasers are classified according to their

1. Sources:
    a. Gas Lasers
    b. Crystal Laser
    c. Semiconductors Lasers
    d. Liquid Lasers
2. Nature of emission:
    a. Continuous Wave
    b. Pulsed Laser
3. Wavelength:
    a. Visible Region
    b. Infrared Region
        i. Far infrared
        ii. Near-infrared
    c. Ultraviolet Region
4. Site of action:
    a. Soft tissue lasers
    b. Hard tissue lasers

2.1.1.2.1 Gas lasers:

A gas laser is a laser in which an electric current is discharged through a gas to produce coherent light. The gas laser was the first continuous-light laser and the first laser to operate on the principle of converting electrical energy to a laser light output. The He-Ne gas laser was the first gas laser introduced; since then, several other gas discharges have been found to amplify light coherently and have been built and used for numerous purposes. The helium-neon Laser (He-Ne) can function at several different wavelengths. However, the majority work at 633 nm. The He-Ne is comparatively low cost but is a highly coherent laser. The Commercial carbon dioxide (CO2) lasers can emit hundreds of watts in a single spatial mode that can be concentrated into a tiny spot (Endo and Walter, 1966).

2.1.1.3 Argon laser:

The argon-ion laser was invented in 1964 by William Bridges at the Hughes Aircraft Company. One of the ion lasers uses a noble gas as the active medium. Argon-ion lasers are used for retinal phototherapy (for the treatment of diabetes). The argon laser operates at a wave length of 457 to 502 nm, using a pulsed or continuous waveform. The argon laser can be used for various applications, including resin curing and tooth bleaching. In addition, this laser has several soft-tissue applications, including gingival troughing, aesthetic contouring of gingiva, treatment of oral ulcers, frenectomy and gingivectomy (Verma *et al.*, 2012).

The primary advantage of the argon laser is that the laser operates at a wavelength absorbed by haemoglobin, which provides excellent haemostasis. However, dentists should be aware that argon lasers do not necessarily produce a resin with physical properties superior to resins cured with traditional halogen curing lights when used for resin. In addition, some resins contain multiple initiators that activate at different wavelengths suggesting that the relatively narrow spectrum of a laser might not be the best approach to activate the initiators (Timimi and Alhabeel, 2019).

2.1.1.4 Semi-conductor-diode lasers:

Diode lasers are quite popular due to their compact size and relatively affordable pricing. A specialised semiconductor that produces monochromatic light when stimulated electrically is common to all diode lasers. A simple laser pointer is an example of a diode laser. Diode lasers can be used in contact and non-contact modes and function with a continuous wave or gated pulse modes. However, they are not capable of free-running pulsed mode (Deppe *et al.*, 2021).

Diode lasers are invisible near-infrared wavelengths, and current machines range from 805 -1064 nm. One exception is the Diagnodent caries diagnostic laser which uses a visible red wavelength of 655 nm. Diode lasers are used for soft tissue only. The chromophores are pigments like haemoglobin and melanin, similar to the Nd: YAG absorption spectrum. They also exhibit bactericidal capabilities and can be used for adjunctive periodontal procedures. They also are used for Laser-assisted tooth whitening. Diode lasers also have photobiomodulation properties (Heiskanen and Hamblin, no date).

2.1.1.5 Gallium-arsenide/diode:

This type of diode laser operates at a wavelength of 904 nm, using a pulsed or continuous waveform and has proven successful with soft-tissue incision and ablation. Gallium-arsenide/diode Laser has been used for the following: gingival troughing, aesthetic contouring of gingival, treatment of oral ulcers, frenectomy and gingivectomy. This diode laser does not affect the inflammatory function of monocytes or endothelial cells or the adhesion of endothelial cells. In addition, it can kill some microbes in the presence of photosensitisers and some fungi in the presence of some dye photosensitisers. Finally, within certain low-energy ranges, the diode laser can stimulate the proliferation of fibroblasts (Yilmaz *et al.*, 2002).

2.1.2. Components of laser unit:

- Active Medium
  - Gas- CO2, Argon, Krypton
  - Solid- Ruby, Nd: YAG, Er: YAG
  - Liquid- Organic dye, Rhodium • Semiconductor- Diode
  - Laser Resonator
- The active medium is contained within the optical enclosure.

Power Source Active medium needs to be changed to release photons. The external energy source may be an electrical, chemical, or flash lamp. Next, an external energy source pumps the gain medium. The gain medium emits photons, which bounce back and forth between the reflectors. Finally, part of the radiation can exit through an aperture in one of the reflectors, resulting in the laser beam.

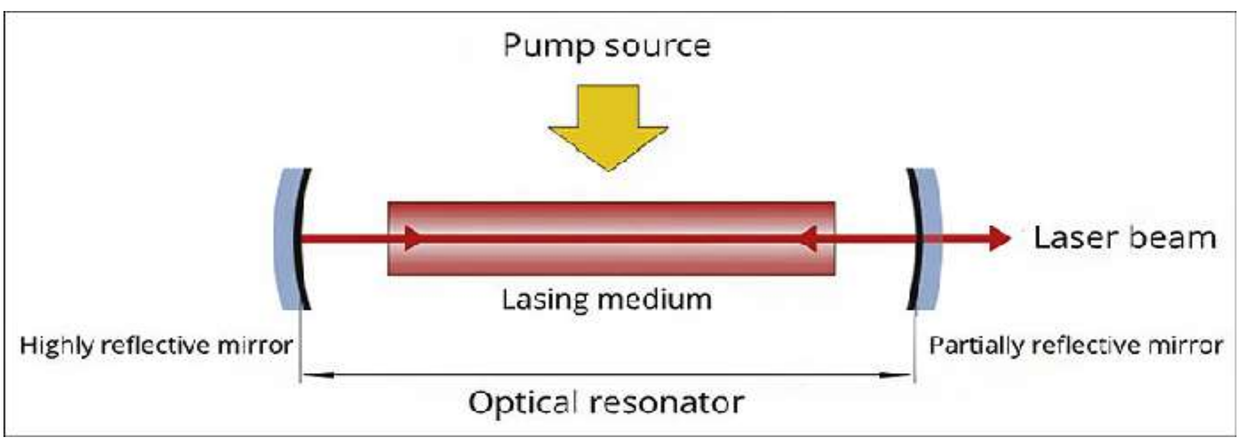


Figure 2: Schematic drawing showing the main components of a laser

2.1.3. Spontaneous emission:

When this pumping mechanism pumps energy into the active medium, the energy is absorbed by the electrons in the outermost shell of the active medium's atoms. These electrons have absorbed a specific amount of energy to reach the next shell farther from the nucleus, at a higher energy level. A "population inversion" occurs when more of the electrons from the active medium is in the higher energy level shell farther from the nucleus than are in the ground state. The electrons in this excited state then spontaneously give off that energy in the form of a photon, Known as the spontaneous emission.

2.1.4. Emission mode of lasers:

Dental laser devices can emit light energy in two modalities as a function of time:

1. Constant / Continuous
2. Pulsed
   a. Gated-pulse mode
   b. Free-running pulsed mode

2.1.4.1 Continuous-wave mode:

Lasers depend on a beam whose output power is constant over time and steady when averaged over any longer time periods, with a very high frequency. The power variations had little or no impact on the intended application. Such a laser is known as the continuous wave. Many lasers can be made to operate in continuous wave mode to satisfy such an application. The beam is emitted at only one power level if the operator depresses the footswitch.

2.1.4.2 Gated-pulse mode:

There are periodic alternations of the laser energy, similar to a blinking light. This mode is achieved by opening and closing a mechanical shutter in front of a continuous-wave emission beam path. All surgical devices that operate in continuous wave have this gated-pulse feature. The more advanced units have computer-controlled shutters that allow these very short pulses. Manufacturers have coined many terms to describe these short pulse durations, including "super pulse" and "ultra-speed."

2.1.4.3 Free-running pulsed mode:

It is also referred to as true-pulsed mode. This emission is unique in that large peak energy of laser light is emitted for usual microseconds, followed by a relatively long time in which the Laser is off. These devices have a rapidly striking flash lamp that pumps the active medium. High peak powers in hundreds or thousands of watts are generated with each pulse. However, because the pulse duration is short, the average power the tissue experiences is small. Free-running pulsed devices cannot have a continuous-wave or gated-pulse output.

2.1.4.4 Contact mode

The terminal end of the fibro-optic is placed in direct contact with the target tissue, and the operator will have tactile feedback.

2.1.4.5 Non-contact mode

The handpiece is held away from the tissue, and the operator has to adjust the beam's focus by varying the distance between the handpiece and target to have the desired effect.

2.1.5. Laser-Tissue Interaction (Yilmaz *et al.*, 2002)

Laser light has four different interactions with the target tissue, depending on the optical properties of that tissue, as follows:

- Absorption
- Transmission
- Reflection
- Scattering

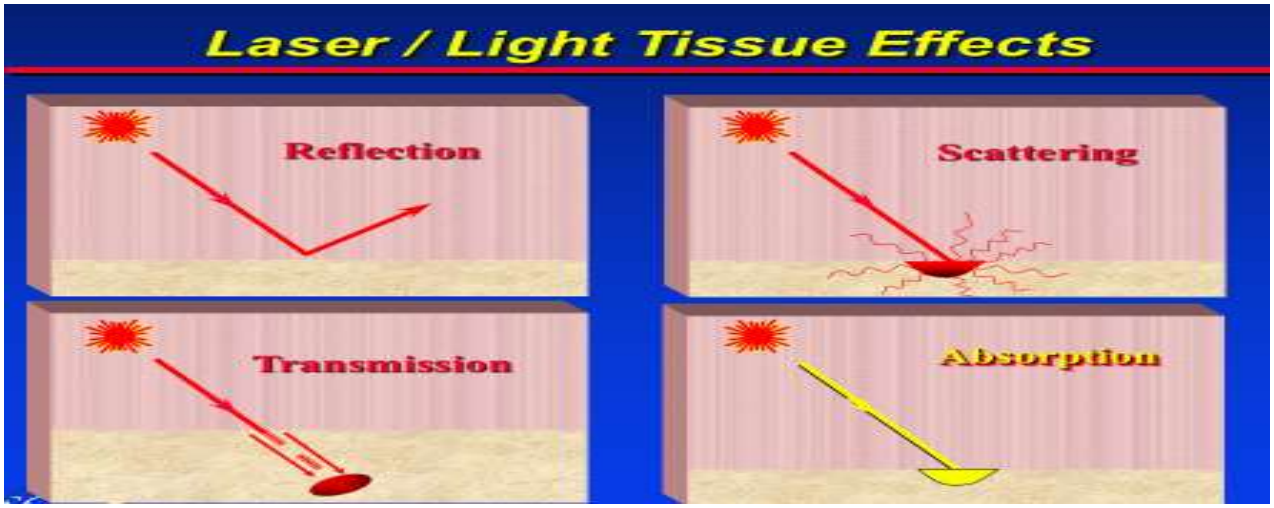


Figure 3: Schematic diagram showing laser-tissue interaction

2.1.5.1 Absorption

Laser light is converted into effective thermal energy. The energy absorbed by the tissue depends on the tissue characteristics, such as pigmentation and water content, the laser wavelength and emission mode. The shorter wavelengths are readily absorbed in pigmented tissue and blood elements. Longer wavelengths are more interactive with water and hydroxyapatite.

2.1.5.2 Transmission:

The light energy passes freely through the tissue without interaction and has little or no effect. It is an inverse of absorption.

2.1.5.3 Reflection:

Light energy reflects off tissue surface with little or no absorption and does not affect tissue. However, the laser beam becomes more divergent as the distance from the headpiece increases, which becomes dangerous because the energy is directed to an unintentional target such as the eye –a major safety concern for laser operation.

2.1.5.4 Scattering:

Light energy is re-emitted in a random direction and ultimately absorbed over a greater surface area, producing a less intense and less precisely distributed thermal effect. When laser light emerges from a laser, it usually enters in the form of a pencil-thin beam of energy travelling at the speed of light. This beam travels in a straight line until it hits something that reflects or refracts it or until it hits something that stops it and absorbs its energy. Then, the laser beam diverges gradually as it travels away from the laser, which means that the beam's diameter increases with the distance between the handpiece and the target tissue.

2.2. TISSUE CHANGES WERE SEEN IN LASER THERAPY LASER:

Five important biological effects can occur once the laser photons enter the tissue: fluorescence, photothermal, photo-disruptive, photochemical, and photobiomodulation. Fluorescence happens when an actively carious tooth structure is exposed to the 655 nm visible wavelength. The amount of fluorescence is related to the size of the lesion and is useful in diagnosing incipient carious lesions. e.g., Diagnodent Photothermal effects occur when the chromophores absorb the laser energy and generate heat. This heat works such as incising tissue or coagulating blood.

Photothermal interactions predominate when most soft tissue procedures are performed with dental lasers. Heat is generated during these procedures, and great care must be taken to avoid thermal damage to the tissues. Photodisruptive effects: Hard tissues are removed through a process known as photodisruptive ablation. Short-pulsed bursts of laser light with extremely high power interact with water in the tissue and the handpiece, causing rapid thermal expansion of the water molecules.

The pulsed Erbium laser ablation efficiency seems to result from these microexplosions of overheated tissue water in which their laser energy is predominantly absorbed. Thus tooth and bone are not vaporised but pulverised through the photomechanical ablation process. This shock wave creates the distinct popping sound heard during erbium laser use. Thermal damage is unlikely as almost no residual heat is created when used properly, particularly when thermal relaxation is considered. Photochemical reactions occur when photon energy causes a chemical reaction. These reactions are implicated in some of the beneficial effects of biostimulation: e.g., Photodynamic therapy.

Photobiomodulation (Biostimulation) indicates the laser's ability to speed healing, increase circulation, reduce oedema, and minimise pain. The exact mechanism of these effects is unclear, but it is theorised that they occur mostly through photochemical and photobiological interactions within the cellular matrix and mitochondria. Biostimulation is used dentally to reduce postoperative discomfort and to treat disorders such as recurrent herpes and aphthous stomatitis, e.g., Low-Level Laser Therapy (LLLT) (Farivar, Malekshahabi and Shiari, 2014)

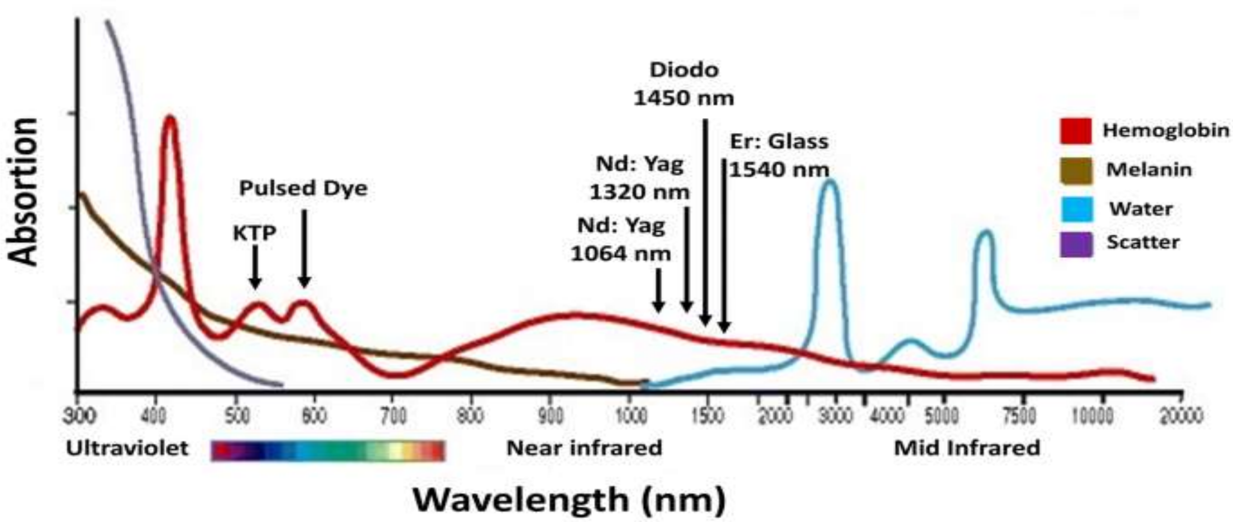


Figure 4: Absorption patterns of the chromophores water, melanin, and haemoglobin

Generally, different laser wavelengths have different absorption coefficients, with the primary oral tissue components of water, pigment, blood contents, and minerals. Thus, laser energy can be transmitted, absorbed, scattered, or reflected based on the composition of the target tissue.

The primary components are chromophores, which are absorbers of specific laser energy. Water, present in all biologic tissue, maximally absorbs the two erbium wavelengths, followed by the CO2 wavelength. Conversely, water allows the transmission of the shorter-wavelength lasers (e.g., Diode, Nd: YAG). Photothermal interactions predominate, whereby diode tissue cutting is via thermal energy. They are quite effective for intraoral soft tissue procedures such as gingivectomy, biopsy, impression troughing, and frenectomy. Haemoglobin and other blood components and pigments such as melanin absorb Diode and Nd: YAG in varying amounts (Lee *et al.*, 2019).

Tooth enamel is composed of hydroxyapatite and water. The hydroxyapatite crystal readily absorbs the CO_2 wavelength and interacts less with the Erbium wavelengths, which do not interact with the shorter wavelengths.7 For hard tissue, the erbium lasers with very short pulse durations easily ablate layers of calcified tissue with minimal thermal effects. Suppose soft tissue intrudes into a carious lesion. In that case, an erbium laser can remove the lesion and the soft tissue very efficiently as long as appropriate settings are used for each tissue type. In addition to unique absorptive optical properties, all wavelengths have different penetration depths through tissue. For example, the Erbium and CO2 lasers are so well absorbed by tissue with a high-water content (e.g., mucosa) that these wavelengths penetrate only a few to several microns deep into the target tissue, whereas Diode and Nd:YAG lasers can reach a few millimetres deeper into the tissue (Patil and Dhami, 2008).

2.2.1. Advantages of using lasers in periodontal therapy:

1. Less pain.
2. Less need for anaesthetics (an advantage for medically compromised patients)
3. No risk of bacteraemia
4. Excellent wound healing; no scar tissue formation
5. Bleeding control (dependent on the wavelength and power settings)
6. Usually, no need for sutures
7. Use of fewer instruments and materials
8. Ability to remove both hard and soft tissues
9. Lasers can be used in combination with scalpels

2.2.2. Disadvantages of using lasers in periodontal therapy:

1. Relatively high cost of the devices
2. A need for additional education (especially in basic physics)
3. Every wavelength has different properties
4. The need to implement safety measures (e.g., goggles use, warning signs on the door, reflecting surfaces etc.)(Patil and Dhami, 2008; Verma *et al.*, 2012)

Alves *et al.* conducted a randomised split-mouth clinical trial to evaluate the efficacy of scaling and root planing associated with the high-intensity diode laser on periodontal therapy through clinical parameters and microbial reduction. The study selected 36 chronic periodontitis subjects of both genders. Each subject chose one pair of contralateral single-rooted teeth with pocket depth >5 mm. All patients received non-surgical periodontal treatment, after which the experimental teeth were designated to either test or control groups. Both teeth received scaling, root planing and coronal polishing (SRP) and teeth assigned to the test group (SRP + DL) were irradiated with the 808 ± 5 nm diode laser, for 20 s, in two isolated appointments, one week apart. The laser was used in the continuous mode, with 1.5 W and a power density of 1,193.7 W/cm(2). Clinical and microbiological data were collected at baseline, six weeks and six months after therapy. The results demonstrated a significant improvement of all the clinical parameters- clinical attachment level (CAL), probing depth (PD), plaque index (PI) and Bleeding on Probing (BOP)-for both groups ($P < 0.001$), with no statistical difference between them at the six weeks and the six months examinations. As for microbiological analysis, a significant reduction after six weeks ($P > 0.05$) was observed as far as colony forming units (CFU) are concerned for both groups. As for black-pigmented bacteria, a significant reduction was observed in both groups after six months. However, the difference between the test and control groups was not significant. Furthermore, there was no association between the group and Porphyromonas gingivalis, Prevotella intermedia and Aggregatibacter actinomycetemcomitans. After six months of evaluation, the authors concluded that the high-intensity diode laser has no additional benefits to the conventional periodontal treatment (Euzebio Alves *et al.*, 2013).

The use of laser is one of the most recent methods in non-surgical periodontal treatment. However, each type of laser treatment's efficacy and side effects have yet to be determined. The study evaluated the clinical efficacy of the Indium Gallium Arsenide Phosphide diode laser as an adjunct to traditional SRP. Thirty patients suffering from the moderate periodontal disease had included in the study. They were randomly selected to undergo SRP with curettes or SRP combined with Indium Gallium Arsenide Phosphide laser (980 nm and 2 W). The papilla bleeding index, bleeding on probing, and clinical attachment level was registered at baseline and six weeks. Results show that the papilla bleeding index average in the group treated with Laser was 0.24 versus 0.43 under conventional treatment; in the group undergoing SRP, bleeding on probing decreased to 19.55% less than in the group treated with Laser. Nevertheless, clinical attachment level differences cannot be considered significant between both groups. So they concluded that SRP in combination with Laser produces a moderate clinical improvement over traditional treatment (Leyes Borrajo *et al.*, 2004).

Kreisler *et al.* aimed to study the clinical efficacy of semiconductor laser periodontal pocket irradiation as an adjunct to conventional SRP and examined the clinical efficacy of semiconductor laser periodontal pocket irradiation as an adjunct to conventional SRP. Twenty-two healthy patients needing periodontal treatment with at least four teeth in all quadrants were included. All of them underwent SRP. Using a split-mouth design, two randomly chosen quadrants (one upper and the corresponding lower one) were subsequently treated with an 809 nm Gallium Aluminium Arsenide Laser at a power output of 1.0 Watt using a 0.6 mm optical fibre. The teeth in the control quadrants were rinsed with saline. The clinical outcome was evaluated using Plaque Index, Gingival Index, bleeding on probing, sulcus fluid flow rate, tooth mobility (Periotest), pocket depth and clinical attachment loss at baseline and three months after treatment. Results show that teeth treated with the Laser revealed a significantly higher reduction in tooth mobility, pocket depth, and clinical attachment loss. Twelve percent of the teeth in the laser group showed an attachment gain of 3 mm or more, compared to 7% in the control group. An attachment gain of 2–3 mm was found in 24% of the teeth in the laser group and 18% in the control group. However, no significant group differences could be detected for the Plaque Index, Gingival Index, bleeding on probing, and the sulcus fluid flow rate. They concluded that a higher reduction in tooth mobility and probing depths is probably not predominantly related to a bacterial reduction in the periodontal pockets. The de-epithelisation of the periodontal pockets leads to an enhanced connective tissue attachment. The diode laser's application in treating inflammatory periodontitis at the irradiation parameters described above is a safe clinical procedure. Therefore, it was recommended as an adjunct to conventional SRP (Kreisler, Al Haj and D'Hoedt, 2005).

Pejcic *et al.* conducted a histological examination of gingiva treated with conventional therapy and a low-power Laser. Thirty patients diagnosed with chronic periodontitis were examined. In the experimental group, fifteen patients were treated with SRP, followed by therapy with a low-level Laser. In contrast, the control group patients were treated only with SRP. In addition, the gingival biopsy material was examined at the Institute of Pathology of the Faculty of Medicine. After SRP, histological findings of gingivae showed a reduction in the number of inflammatory cells and partial stroma collagenisation, while histological findings of gingivae after laser therapy indicated completely regenerated gingival tissue with few inflammatory cells as well as marked collagen tissue homogenisation. Based on the results, it can be concluded that laser therapy as an adjunct procedure in treating periodontitis successfully reduces gingival tissue inflammation (Kreisler, Al Haj and D'Hoedt, 2005).

Periodontal therapy's primary goal is to remove supra and subgingival bacterial deposits by mechanical debridement consisting of SRP using manual or power-driven instruments. This study aimed to compare the effectiveness of Diode laser used as adjunctive therapy of SRP to that of SRP alone for non-surgical periodontal treatment in patients with chronic periodontitis. Nineteen pairs of teeth with untreated chronic periodontitis were selected in 13 patients and randomly treated by SRP alone (control group) or by SRP + laser irradiation (test group). Clinical measurements (PPD, CAL, BOP, GI, PI) were performed before treatment at baseline (T0) and T1 (after four weeks), T2 (8 weeks), T3 (12 weeks), T4 (6 months). In addition, subgingival plaque samples were taken at baseline and after treatment and examined for eight periopathogens bacteria using the PCR technique. The present study showed that the additional treatment with diode laser might slightly improve clinical parameters. Still, no significant differences were found between the test and control groups in reducing periodontopathogens. The authors showed that the additional treatment with diode laser might slightly improve clinical parameters. In contrast, no significant differences between the test and control groups in reducing periodontal pathogens were found (Caruso *et al.*, 2008).

Micheli *et al.* conducted the split-mouth study, where twenty-seven patients were randomly assigned into two groups. The control group underwent SRP, whereas the experimental group received diode laser irradiation. The irradiation was done using 808± 5 nm wavelength on days 1 and 7 following SRP. The clinical parameters assessed were clinical attachment level, clinical probing depth, Plaque Index and Bleeding on Probing. Microbiologically, the collected subgingival plaque samples were analysed for periodontal pathogens. At six weeks, clinical probing depth demonstrated a significant reduction in clinical attachment levels, but there was no significant difference between groups. The same trend was observed regarding the Plaque index and Bleeding on Probing. Six months following the procedure, there was a reduction in colony-forming units in both groups, but the bioburden was no significant difference between groups. They concluded that adjunct to SRP doesn't have additional benefits over SRP when a diode laser is used (De Micheli, De Andrade, *et al.*, 2011).

Dukic *et al.* evaluated the effect of a 980-nm diode laser as an adjunct to SRP treatment. Thirty-five patients with chronic periodontitis were selected for the split-mouth clinical study. Quadrants were equally divided between the right and left sides. Subsequently, two control quadrants of SRP were done using hand instruments, curettes, and the sonic device. The other two contralateral quadrants were treated similarly with a diode laser. Laser treatment was performed using a diode laser 980nm with a 300 µm fibre, introduced parallel to the tooth surface for 20 seconds per tooth. The laser settings followed were; power 2 W, time on 25 ms, and time off 50 ms. Laser therapy was applied to periodontal pockets on days 1, 3, and 7 after SRP. At Baseline, Approximal Plaque Index, 20 bleeding on probing, probing depth, and clinical attachment level were recorded before and 6 and 18 weeks after treatment. Changes in probing depth, and clinical attachment level, were analysed separately for initially moderate and deep pockets. The results were similar for groups regarding Approximal Plaque Index, bleeding on probing, depth in deep pockets, and clinical attachment level. The laser group showed only significant probing depth gain in moderate pockets during the baseline to 18 weeks and 6- to 18-week periods. No difference was found between groups in the remaining clinical parameters. They concluded that, compared to SRP alone, multiple adjunctive applications of a 980-nm diode laser with SRP showed probing depth improvements only in moderate periodontal pockets (Dukić *et al.*, 2013).

Zare *et al.* study; evaluated the effect of the Diode laser on gingival inflammation when used between the first and second phase of periodontal treatment, compared with the common SRP modality alone. Twenty-one patients with moderate to severe chronic periodontitis were selected and divided into SRP and test groups adjunct with Laser. Two months after the last scaling and laser radiation, indexes including gingival level, bleeding on probing and modified gingival index were recorded and compared with baseline. Results show that all indices improved in both groups at the end of two months. The indices were not different between the two groups except for bleeding on probing, which was lower in the laser group. They concluded that overall improvement in parameters such as the superiority of laser application in some indices, lack of thermal damage and gingival recession with the specific settings used in this study, the application of Laser as an adjunctive treatment, and common methods is preferable (Zare *et al.*, 2014).

Arisan *et al.* (2015)28 investigated the efficacy of a diode laser as an adjunct to conventional scaling in the non-surgical treatment of peri-implantitis, both radiographic and microbiological methods. Ten patients with 48 two-piece, rough surface implants diagnosed with peri-implantitis were recruited. In addition to conventional scaling and debridement (control group), crevicular sulci and the corresponding surfaces of 24 random implants were lased by a diode laser running at 1.0 W power at the pulsed mode, wavelength 810 nm; energy density, 3 J/cm2; time, 1 min; power density, 400 mW/cm2; energy, 1.5 J; (laser group). Healing was assessed via periodontal indexes (baseline and after 1 and 6 months after the intervention), microbiologic specimens (baseline and after one month), and radiographs (baseline and after six months). Baseline mean pocket depths and marginal bone loss were similar between the control and laser groups. After six months, the laser group revealed higher marginal bone loss than the control group. However, in both groups, the microbiota of the implants was found unchanged after one month. They concluded that adjunct use of diode laser did not yield any additional positive influence on the peri-implant healing compared with conventional scaling alone. (Arlsan *et al.*, 2015)

Lobo *et al.*, Lasers have several potential benefits such as antibacterial effect and wound healing stimulation. In addition, hemostasis and delaying epithelial migration may facilitate the outcome of flap surgery. However, there is minimal research and evidence for the optimum use of a diode laser in flap surgery and its benefit and safety. Hence, this study aimed to investigate the adjunctive effect of diode laser irradiation in open flap debridement (OFD) while treating chronic periodontitis. A total of 30 patients with generalised chronic moderate to severe periodontitis with ≥5 mm post - Phase I therapy were selected for a split-mouth study. Flap surgery with adjunctive diode laser irradiation was performed in the test quadrant, while routine open flap debridement was done in the control quadrant. Clinical parameters including pocket probing depth, clinical attachment level, gingival recession, Plaque Index, Gingival Index and tooth mobility were recorded at baseline, three months and six months following treatment. In addition, patients' ratings of procedural pain and the development of complications postoperatively were assessed. Results show that all clinical parameters significantly improved after therapy without any statistically significant difference between the two groups for any of the parameters. The exception was a significantly greater reduction in gingival inflammation in the Laser treated group. The laser treatment was acceptable to the patient and did not cause complications. They concluded that the diode laser could be safely and effectively used as an adjunct to treating chronic periodontitis with the advantage of decreased gingival inflammation (Arlsan *et al.*, 2015).

Crispino evaluated the effect of a 940- nm diode laser as an adjunct to SRP in patients affected by periodontitis. Sixty-eight patients with mild to moderate periodontitis were included and divided into two groups in which controls received SRP alone. In contrast, the test group had SRP and laser treatment. All patients were examined for clinical parameters like Gingival Index, Plaque Index, and probing depth at baseline and four months. Results show that both groups reported statistically significant differences compared to baseline. Both procedures effectively improved Gingival Index, Plaque Index, and probing depth, but the use of diode laser was associated with more evident results. They concluded that diode laser could be used routinely as an adjunct to SRP regarding the clinical outcome (Crispino *et al.*, 2015).

A study by Nguyen *et al.* compared the effectiveness of SRP with the adjunctive use of diode laser therapy to SRP alone on changes in the clinical parameters and the gingival crevicular fluid inflammatory mediator interleukin-1β in patients receiving regular periodontal maintenance therapy. This study includes twenty-two patients receiving regular periodontal maintenance therapy with one or more periodontal sites with a probing depth ≥5 mm bleeding on probing. The treated test and control sites are fifty-six and fifty-eight sites, respectively. Clinical parameters, including probing depth, clinical attachment level, bleeding on probing, and gingival crevicular fluid interleukin -1β levels, were measured immediately before and three months after treatment. Gingival crevicular fluid was collected using filter paper strips and was analysed for interleukin-1β using an enzyme-linked immunosorbent assay. After all the SRP, the test sites were treated with diode laser therapy, following the manufacturer's guidelines to scrape the inner epithelial lining of the pocket with a curette to reduce the subgingival bacterial load. The power setting was at 0.80 W, wavelengths at 940 nm in continuous wave mode. Results show that both sites treated had statistically significant reductions in probing depth and bleeding on probing and gains in clinical attachment level. These changes were not significantly different between the two therapies. Similarly, differences in interleukin-1β levels between the two groups were not statistically significant. They concluded that adjunctive diode laser therapy to SRP did not enhance clinical outcomes in treating inflamed sites with ≥5 mm probing depth in periodontal maintenance patients (Nguyen *et al.*, 2015).

3. CHAPTER THREE MATERIALS AND METHOD

3.1. STUDY DESIGN:

Observation analytical clinical trial with split-mouth technique

3.2. STUDY AREA:

Best care hospital

3.3. STUDY POPULATION:

In this study, initially, ten patients of age 30-50 years were selected and underwent full mouth SRP

3.4. METHODOLOGY (ELIGIBILITY CRITERIA OF PARTICIPANTS):

3.4.1. Inclusion criteria:

- Periodontitis stage III
- Age -30-35 years and above
- Periodontal pocket > 5mm
- Clinical attachment level 4 mm
- Radiographic evidence of bone loss

3.4.2. Exclusion criteria:

- Patients with uncontrolled systemic diseases
- Patients underwent periodontal therapy within six months.
- Use of antibiotics and anti-inflammatory drugs in the previous six months.
- Pregnant, Lactating women. 5.
- Grade III/IV mobility.

3.5. SAMPLING TECHNIQUE:

The study procedure was explained to the participants in Arabic. Written consent was obtained from all participants, and Oral hygiene instructions were given. The clinical parameters recorded are the Plaque index (PlI) (Silness and Löe 1964) (Silness and Löe, 1964), Gingival index (GI) (Löe and Silness 1963) (Löe, H., Silness, 1963). Probing pocket depth (PPD) (Glavind and Löe 1967) (Glavind and Löe, 1967) was measured from the gingival margin to the base of the periodontal pocket. Clinical attachment level (CAL) (Glavind and Löe 1967) (Glavind and Löe, 1967) was measured from the cementoenamel junction (CEJ) to the base of the pocket. All the measurements were made by a single examiner (HAM) using a graduated William's periodontal probe to the nearest millimetre. The PPD and CAL were measured at six sites for all the present teeth, mesiobuccal, mid buccal, distobuccal, mesiolingual, midlingual, and distolingual. These measurements were made at baseline and months.

3.5.1. Laser decontamination procedure:

Following infiltration, anaesthesia, full mouth scaling, and root planing (SRP) were done using an ultrasonic scaler and manual Gracey curettes. After thorough SRP, laser decontamination was done using a Diode laser (quick lase). Again, all the safety precautions provided by the manufacturer were followed.

A 200 µm flexible fiberoptic glass fibre was inserted into the pocket's base and held parallel to the tooth surface. The laser beam was aimed at the soft tissue lining of the pocket and not toward the tooth surface. The fibre was moved around the tooth from the base of the pocket in an apico-coronal direction, making overlapping horizontal and vertical movements with continuous soft tissue contact. The laser settings were set as follows a Wavelength - 980 nm Mode of Application- 2.0 W pulsed mode (25 msec on/50 msec off) for avg power of 0.7 W applied 20 sec/tooth

3.6. STUDY VARIABLES:

Independent Variables:	Dependent Variables:
Demographical characteristics (age and gender)	
Periodontal parameters (GI, PPD, CAL and BOP)	
Periodontitis	

3.7. DATA COLLECTION TOOLS AND TECHNIQUES:

A data collection form will interview the participants and record periodontal parameters. The collected data will include the participants, demographic data, medical and dental history, oral health characteristics, habits, and examination findings.

The periodontal examination will include all teeth present, and the following periodontal parameters will be measured.

- Gingival index (GI), according to Löe and Silness (1963)
- Plaque Index (PI), according to Silness and Löe (1964)
- Probing Pocket Depth (PPD), according to Glavind and Löe (1967)
- Clinical attachment level (CAL), according to Glavind and Löe (1967)

The examinations will be carried out using dental mirrors, and a graduated Williams periodontal probe for all teeth on six points (mesiobuccally, mid buccal, distobuccally, mesiolingually, mid lingual, dentilingual), partially erupted teeth, retained root, teeth with a periapical lesion, and third molars will be excluded. Also, the dental examination will be carried out on a dental chair.

3.8. MATERIALS NEEDED FOR DATA COLLECTION:

- Mouth mirror
- Williams periodontal probe
- Tweezer
- Cheek retractor
- Cotton rolls
- Suction tip
- Local anaesthetic solution-lignocaine with adrenaline 1: 80,000
- 3 ml disposable syringe.
- Gauze pieces
- Gracey curettes
- Diode laser
- Ultra-sonic scaler

4. CHAPTER FOUR RESULTS AND DISCUSSION

4.1. RESULTS

The mean plaque index on the right side at the baseline was 1.25and after one month was 0.16. The Mean gingival index on the right side at the baseline was 1.16, and after one month was 0.3. the Mean pocket depth on the right side at the baseline was 1.6, and after one month, it was 1.4. the Clinical attachment loss on the right side at the baseline was 2.9 and after one month was 1.9 Mean plaque index on the side at the baseline was 1.05, and after one month was 0.05 Mean gingival index on the left side at the baseline was 1.3, and after one month was 0.08 the Mean pocket depth on the left side at the baseline was 2.0 mm. After one month was 0.5 mm, the Clinical attachment loss on the left side at the baseline was 2.7 mm, and after one month was 1.01 mm.

4.2. DISCUSSION

According to our results, Laser therapy slightly impacts pocket depth reduction, which minimised the PD measurement to the normal level (1 to 3 mm). However, the responses to Diode Laser therapy show that most of the case group (Laser group) patients, which was 95%, have an improvement effect after laser treatment despite the SRP. Another study conducted by Crispino A 2015 (Crispino et al. 2015) reported that both SRP associated with Diode Laser therapy procedures were effective in improving the GI, PI, and PD. On the other hand, De Micheli. et al. (De Micheli, de Andrade, *et al.*, 2011) found that using the two therapeutic procedures (SRP and Laser therapy) are similar and lead to no additional benefits or improvement. However, laser therapy showed an improvement in PD but only in moderate to severe periodontitis cases.

4.3. CONCLUSIONS

Our study showed changes in pocket depth parameters clinically, although it's not statistically significant, Considered the better clinical results, the laser diode can be routinely associated with the traditional mechanical non-surgical therapy (SRP) in the treatment of periodontal pockets of patients with moderate-to-severe chronic periodontitis. Such studies encourage us to hope that using complementary low-power lasers in the future will become a part of the standard protocol of non-surgical periodontal therapy.

4.4. LIMITATIONS OF THE STUDY

1. Need more time for a re-evaluation of the clinical parameters
2. Need more patients

4.5. RECOMMENDATIONS

Further evaluation on the optimisation of both dose (frequency in nm) and frequency (number of treatments) in larger sample size and varying simulations should be carried out in future for corroboration of results

REFERENCES:

Andersen, G.I. (2020) 'History and Foundations of Laser Physics', (April). doi:10.13140/RG.2.2.24504.70400.

Arlsan, V. *et al.* (2015) 'A randomised clinical trial of an adjunct diode laser application for the non-surgical treatment of peri-implantitis', *Photomedicine and laser surgery*, 33(11), pp. 547–554. doi:10.1089/PHO.2015.3956.

Caruso, U. *et al.* (2008) 'Use of diode laser 980 nm as adjunctive therapy in the treatment of chronic periodontitis. A randomised controlled clinical trial', *New Microbiologica*, 31(4), pp. 513–518.

Cobb, C.M. (2006) 'Lasers in Periodontics: A Review of the Literature', *Journal of Periodontology*, 77(4), pp. 545–564. doi:10.1902/jop.2006.050417.

Crispino, A. *et al.* (2015) 'Effectiveness of a diode laser in addition to non-surgical periodontal therapy: study of intervention', *Annali di Stomatologia*, 6(1), p. 15. doi:10.11138/ads/2015.6.1.015.

Deppe, H. *et al.* (2021) 'Thermal effect of a 445 nm diode laser on five dental implant systems: an in vitro study', *Scientific Reports 2021 11:1*, 11(1), pp. 1–11. doi:10.1038/s41598-021-99709-8.

Dukić, W. *et al.* (2013) 'Clinical Effectiveness of Diode Laser Therapy as an Adjunct to Non-Surgical Periodontal Treatment: A Randomised Clinical Study', *Journal of Periodontology*, 84(8), pp. 1111–1117. doi:10.1902/jop.2012.110708.

Endo, M. and Walter, R.F. (1966) 'Gas lasers', *Applied optics*, 5(10), pp. 1–556. doi:10.1364/AO.5.001500.

Euzebio Alves, V.T. *et al.* (2013) 'Clinical and microbiological evaluation of high intensity diode laser adjutant to non-surgical periodontal treatment: a 6-month clinical trial.', *Clinical oral investigations*, 17(1), pp. 87–95. doi:10.1007/s00784-012-0703-7.

Farivar, S., Malekshahabi, T. and Shiari, R. (2014) 'Biological Effects of Low Level Laser Therapy', *Journal of Lasers in Medical Sciences*, 5(2), p. 58.

G. Caton, J. *et al.* (2018) 'A new classification scheme for periodontal and peri-implant diseases and conditions – Introduction and key changes from the 1999 classification', *Journal of Clinical Periodontology*, 45, pp. S1–S8. doi:10.1111/JCPE.12935.

Glavind, L. and Löe, H. (1967) 'Errors in the clinical assessment of periodontal destruction', *Journal of periodontal research*, 2(3), pp. 180–184. doi:10.1111/J.1600-0765.1967.TB01887.X.

Gursel, A.T. (2018) 'Fiber Lasers and Their Medical Applications', *Optical Amplifiers - A Few Different Dimensions* [Preprint]. doi:10.5772/INTECHOPEN.76610.

Hashim, N.T. (2018) 'Oral Microbiology in Periodontal Health and Disease', *Oral Microbiology in Periodontitis* [Preprint]. doi:10.5772/INTECHOPEN.75709.

Hashim, N.T. (2018) 'Oral Microbiology in Periodontal Health and Disease', *Oral Microbiol Periodontitis* [Preprint].

Heiskanen, V. and Hamblin, M.R. (no date) 'Photobiomodulation: Lasers vs Light Emitting Diodes?' doi:10.1039/c8pp00176f.

Ivanova, N. *et al.* (2016) 'Laser Applications in Periodontology', in *Intech*, p. 13.

Ivanova N, Gugleva V, Dobreva M, Pehlivanov I, Stefanov S, A. V (2016) 'Laser Applications in Periodontology', in *Intech*, p. 16.

Jawad, M.M. *et al.* (2011) 'An overview: Laser applications in dentistry', *International Journal of Pharmacology*, pp. 189–197. doi:10.3923/ijp.2011.189.197.

Kornman, K.S. (2008) 'Mapping the Pathogenesis of Periodontitis: A New Look', *Journal of Periodontology*, 79(8s), pp. 1560–1568. doi:10.1902/jop.2008.080213.

Kreisler, M., Al Haj, H. and D'Hoedt, B. (2005) 'Clinical efficacy of semiconductor laser application as an adjunct to conventional scaling and root planing', *Lasers in surgery and medicine*, 37(5), pp. 350–355. doi:10.1002/LSM.20252.

Lee, H.C. *et al.* (2019) 'Pattern analysis of 532- and 1,064-nm picosecond-domain laser-induced immediate tissue reactions in ex vivo pigmented micropig skin', *Scientific Reports 2019 9:1*, 9(1), pp. 1–10. doi:10.1038/s41598-019-41021-7.

Leyes Borrajo, J.L. *et al.* (2004)' Diode laser (980 nm) as adjunct to scaling and root planing', *Photomedicine and laser surgery*, 22(6), pp. 509–512. doi:10.1089/PHO.2004.22.509.

Lim, G., Janu, U., Chiou, L-L., Gandhi, K. K., Palomo, L., John, V. (2020) 'Periodontal Health and Systemic Conditions', *Dent. J*, 8(130).

Lim, G. *et al.* (2020) 'Periodontal Health and Systemic Conditions', *Dentistry journal*, 8(4). doi:10.3390/DJ8040130.

Löe, H., Silness, J. (1963) 'Periodontal Disease in Pregnancy. I. Prevalence and Severity', *Acta Odontologica Scandinavica*, 21, pp. 533–551.

Maiman, T.H. (1960) 'Stimulated Optical Radiation in Ruby', *Nature 1960 187:4736*, 187(4736), pp. 493–494. doi:10.1038/187493a0.

Matilainen, V. *et al.* (2014) 'Characterisation of Process Efficiency Improvement in Laser Additive Manufacturing', *Physics Procedia*, 56(C), pp. 317–326. doi:10.1016/J.PHPRO.2014.08.177.

De Micheli, G., De Andrade, A.K.P., *et al.* (2011) 'Efficacy of high intensity diode laser as an adjunct to non-surgical periodontal treatment: a randomised controlled trial', *Lasers in medical science*, 26(1), pp. 43–48. doi:10.1007/S10103-009-0753-5.

De Micheli, G., de Andrade, A.K.P., *et al.* (2011) 'Efficacy of high intensity diode laser as an adjunct to non-surgical periodontal treatment: a randomised controlled trial.', *Lasers in medical science*, 26(1), pp. 43–8. doi:10.1007/s10103-009-0753-5.

Nguyen, N.-T. *et al.* (2015) 'Adjunctive Non-Surgical Therapy of Inflamed Periodontal Pockets During Maintenance Therapy Using Diode Laser: A Randomised Clinical Trial', *Journal of periodontology*, 86(10), pp. 1133–1140. doi:10.1902/JOP.2015.150152.

Patil, U. and Dhami, L. (2008) 'Overview of lasers', *Indian Journal of Plastic Surgery*, 41(3 SUPPL.). doi:10.1055/s-0039-1700481.

Sanz, M. *et al.* (2020a) 'Guest editorial: Clarifications on the use of the new classification of periodontitis', *Journal of Periodontology*, 91(11), p. 1385. doi:10.1002/JPER.20-0166.

Sanz, M. *et al.* (2020b) 'Guest editorial: Clarifications on the use of the new classification of periodontitis', *Journal of Periodontology*, 91(11), p. 1385. doi:10.1002/JPER.20-0166.

Silness, J. and Löe, H. (1964) 'Periodontal Disease in Pregnancy. II. Correlation between Oral Hygiene and Periodontal Condition', *Acta Odontologica Scandinavica*, 22(1), pp. 121–135. doi:10.3109/00016356408993968.

Singh SC, Zeng H, Guo C, C.W. (2012) *Nano materials: Processing and Characterisation with Lasers*. First.

Socransky, Sigmund S., Haffajee, A. (2005) 'Periodontal microbial ecology.: EBSCOhost', *Periodontology 2000*, 38, pp. 135–187.

Timimi, Z.J.M. Al and Alhabeel, M.S.I. (2019) 'Laser Dental Treatment Techniques', *Prevention, Detection and Management of Oral Cancer* [Preprint]. doi:10.5772/INTECHOPEN.80029.

Verma, S. *et al.* (2012) 'Laser in dentistry: An innovative tool in modern dental practice', *National Journal of Maxillofacial Surgery*, 3(2), p. 124. doi:10.4103/0975-5950.111342.

Yilmaz, S. *et al.* (2002) 'Effect of gallium arsenide diode laser on human periodontal disease: a microbiological and clinical study', *Lasers in surgery and medicine*, 30(1), pp. 60–66. doi:10.1002/LSM.10010.

Zare, D. *et al.* (2014) 'Evaluation of the Effects of Diode (980 Nm) Laser on Gingival Inflammation after Nonsurgical Periodontal Therapy', *Journal of Lasers in Medical Sciences*, 5(1), p. 27.

APPENDICES

APPENDIX A INFORMED CONSENT FORM (ARABIC VERSION)

موضوع الدراسه:- بحث علمى لدراسه

تاثير الدايود ليزر بالاضافة الي تحجيم وكشط الجزر في علاج امراض اللثة المزمنة

مقدمة:

يسرنا مشاركتكم فى البحث لنيل درجه الدبلوم العالي من جامعة السودان للعلوم والتكنلوجيا ، واسهاما منكم فى دعم البحوث العلميه نرجو من سيادتكم التكرم بالموافقه على المشاركه فى هذا البحث ،علما بان بيانات البحث تتطلب ملء استبيان لتقيم الصحه، اجراء فحص طبى للاسنان واللثه، جلسات لعلاج التهابات اللثه،

كل المعلومات التى ستجمع ستكون سريه وستستعمل لغرض البحث العلمى فقط. كما ان المشاركه فى البحث ليس له تاثير على الصحه العامه او على الرعايه الصحيه المقدمه ، كما ان لك الحق في الانسحاب من المشاركه دون قيد او شرط ، لقد تم شرح كل المعلومات المتعلقه بالبحث وقد قرات وفهمت المعلومات .

الغرض من البحث :

تاثير الدايود ليزر بالاضافة الي تحجيم وكشط الجزر في علاج امراض اللثة المزمنة ومقارنته بالتحجيم وكشط الجزر فقط

الطريقة :

بعد قبولك للمشاركة في هذه الدراسة سيقيّم طبيبك حالتك لتحديد ما اذا كانت تطابق متطلبات الدراسة.وهذا يتطلب مراجعة تاريخك المرضي واخذ معلوماتك الشخصية وإجراء كشف طبي للأسنان

الآثار الجانبية:

لا توجد اي آثار جانبية تترتب على الدراسة.

الفوائد الممكنة:

تنظيف الاسنان واللثة في حالة المشاركة

التكلفة/استعادة التكلفة:

لن تكلفك الدراسة اي رسوم نقدية.

انهاء المشاركة:

مشاركتك في هذه الدراسة عمل طوعي. ولن تؤثر في سير علاجك اذا قررت عدم المشاركة.

السرية:

لك كل الحق في التمتع بخصوصيتك ونؤكد لك في هذا السياق ان كل المعلومات التي تجمع في اطار هذه الدراسة ستظل سرية وللإستخدام العلمي فقط.

الاتصال بفريق الدراسة:

د. حسين عبد الرحمن مرتضي

رقم الهاتف: 0966247881

او الاتصال بالمشرف علي البحث:

د.امنةالقراي+

الموافقة: – اقر بالآ

1. **.قرأت المعلومات اعلاه وشرح لي كل ما بتعلق بهذه الدراسة البحثية.**
2. **لدي فرصة في طرح الاسئلة وقد تمت الاجابة على كل الاسئلة التي طرحتها.**
3. **.مشاركتي في هذه الدراسة البحثية عمل طوعي.**
4. **.يمكنني الانسحاب من هذه الدراسة في اي وقت دون ان يؤثر ذلك في امكانية حصولي على علاج بديل متوفر.**
5. **.ادرك تماماً انه قد لا تكون لي فائدة طبية مباشرة من المشاركة في هذه الدارسة البحثية.**
6. **ستقدم نسخة موقعة من استمارة الموافقة هذه.**

التوقيع:	**التاريخ**

APPENDIX B: PERIODONTAL PARAMETERS CHART:

- Measurement of the periodontal parameters (GI, PI, PPD, CAL, BOP)

- Six points charting of the patient (GI=gingival index, PI=plaque index, PPD=probing pocket depth, CAL=clinical attachment loss, BOP=bleeding on probing)

Gingival index							
Tooth No.	Tooth surface						Average
	Mesio-facial	Mid-facial	Disto-facial	Disto-oral	Mid-oral	Mesio-oral	
17							#DIV/0!
16							#DIV/0!
15							#DIV/0!
14							#DIV/0!
13							#DIV/0!
12							#DIV/0!
11							#DIV/0!
21							#DIV/0!
22							#DIV/0!
23							#DIV/0!
24							#DIV/0!
25							#DIV/0!
26							#DIV/0!
27							#DIV/0!
37							#DIV/0!
36							#DIV/0!
35							#DIV/0!
34							#DIV/0!
33							#DIV/0!
32							#DIV/0!
31							#DIV/0!
41							#DIV/0!
42							#DIV/0!
43							#DIV/0!
44							#DIV/0!
45							#DIV/0!
46							#DIV/0!
47							#DIV/0!
						Average	#DIV/0!

Plaque index							
Tooth No.	Tooth surface						Average
	Mesio-facial	Mid-facial	Disto-facial	Disto-oral	Mid-oral	Mesio-oral	
17							#DIV/0!
16							#DIV/0!
15							#DIV/0!
14							#DIV/0!
13							#DIV/0!
12							#DIV/0!
11							#DIV/0!
21							#DIV/0!
22							#DIV/0!
23							#DIV/0!
24							#DIV/0!
25							#DIV/0!
26							#DIV/0!
27							#DIV/0!
37							#DIV/0!
36							#DIV/0!
35							#DIV/0!
34							#DIV/0!
33							#DIV/0!
32							#DIV/0!
31							#DIV/0!
41							#DIV/0!
42							#DIV/0!
43							#DIV/0!
44							#DIV/0!
45							#DIV/0!
46							#DIV/0!
47							#DIV/0!
						Average	#DIV/0!

PPD							
Tooth No.	Tooth surface						Average
	Mesio-facial	Mid-facial	Disto-facial	Disto-oral	Mid-oral	Mesio-oral	
17							#DIV/0!
16							#DIV/0!
15							#DIV/0!
14							#DIV/0!
13							#DIV/0!
12							#DIV/0!
11							#DIV/0!
21							#DIV/0!
22							#DIV/0!
23							#DIV/0!
24							#DIV/0!
25							#DIV/0!
26							#DIV/0!
27							#DIV/0!
37							#DIV/0!
36							#DIV/0!
35							#DIV/0!
34							#DIV/0!
33							#DIV/0!
32							#DIV/0!
31							#DIV/0!
41							#DIV/0!
42							#DIV/0!
43							#DIV/0!
44							#DIV/0!
45							#DIV/0!
46							#DIV/0!
47							#DIV/0!
						Average	#DIV/0!

CAL							
Tooth No.	Tooth surface						Average
	Mesio-facial	Mid-facial	Disto-facial	Disto-oral	Mid-oral	Mesio-oral	
17							#DIV/0!
16							#DIV/0!
15							#DIV/0!
14							#DIV/0!
13							#DIV/0!
12							#DIV/0!
11							#DIV/0!
21							#DIV/0!
22							#DIV/0!
23							#DIV/0!
24							#DIV/0!
25							#DIV/0!
26							#DIV/0!
27							#DIV/0!
37							#DIV/0!
36							#DIV/0!
35							#DIV/0!
34							#DIV/0!
33							#DIV/0!
32							#DIV/0!
31							#DIV/0!
41							#DIV/0!
42							#DIV/0!
43							#DIV/0!
44							#DIV/0!
45							#DIV/0!
46							#DIV/0!
47							#DIV/0!
						Average	#DIV/0!

Gingival Bleeding Index							
	Tooth surface						
Tooth No.	Mesio-facial	Mid-facial	Disto-facial	Disto-oral	Mid-oral	Mesio-oral	Average
17							0
16							0
15							0
14							0
13							0
12							0
11							0
21							0
22							0
23							0
24							0
25							0
26							0
27							0
37							0
36							0
35							0
34							0
33							0
32							0
31							0
41							0
42							0
43							0
44							0
45							0
46							0
47							0
						Sum	0
				This number depends on the number of teeth present		No. of surfaces	168
						Percent	0

Appendix C Periodontal Indices

Gingival Index (GI): according to Löe and Silness (1963).

Inspection for signs of gingival inflammation will be done. Partially erupted teeth, retained roots, teeth with a periapical lesion, and third molars should be excluded. No substitution for any missing tooth A graduated William's periodontal probe will be inserted into the gingival crevice along the long axis of the teeth until resistance is felt; then, the probe will be withdrawn and noticed for bleeding according to the following criteria:

0. No inflammation.
1. Mild inflammation, a slight change in colour, slight oedema, no bleeding on probing.
2. Moderate inflammation, moderate glazing, redness, bleeding on probing
3. Severe inflammation, marked redness and hypertrophy, ulceration, and the tendency to spontaneous bleeding.

Plaque index (PI): according to Silness and Löe (1964).

The thickness of plaque will be assessed at the cervical margin of the teeth, on six surfaces of ALL teeth (3rd molars are excluded) will be examined, mesiobuccal, mid buccal, distobuccal, mesiolingual, mid lingual, and distolingual. Partially erupted teeth, retained roots, teeth with a periapical lesion, and third molars should be excluded. No substitution for any missing tooth

0. No plaque.
1. The naked eye cannot see a film of plaque adhering to the free gingival margin and adjacent tooth area. But only by using a disclosing solution or by using a probe.
2. Moderate accumulation of deposits within the gingival pocket, on the gingival margin and/ or adjacent tooth surface, which can be seen with the naked eye.
3. Abundance of soft matter within the gingival pocket and/or on the tooth and gingival margin.

The probing pocket depth (PPD): according to Glavind and Löe (1967).

A William's periodontal probe will be inserted into the gingival sulcus or periodontal pocket close to the long axis of the tooth at six surfaces of each tooth (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual and distolingual surfaces). The distance from the gingival margin to the base of the gingival sulcus or periodontal pockets will be recorded in millimetres

The clinical attachment level (CAL): according to Glavind and Löe (1967).

A William's periodontal probe will be inserted into the gingival sulcus or periodontal pocket close to the long axis of the tooth at six surfaces of each tooth (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual and distolingual surfaces). The distance between the cementoenamel junction (CEJ) and gingival sulcus, or the base of the periodontal pocket, will be measured in millimetres.