Sudan University of Science and Technology

College of Graduate Studies

Institute of Laser

Diode laser (808 nm) Versus Rotary Abrasion in the Treatment of Gingival Hyper Pigmentation (Comparative Study)

ليزر أشباه الموصلات إزاء كشط المكنة الدورانية في معالجة زيادة تصبغ اللثة (دراسة مقارنة)

A Graduation Project Dissertation Submitted as Partial Fulfillment of the Requirements for the Degree of Post Graduate Diploma of Laser Applications in Medicine. Dentistry

By: **Dr. Dalia Ahmed Gasm El Seed Mohammed**

BDS. University of Khartoum, Sudan

MD in Periodontology (Sudan Medical Specialization Board)

Supervisors:

Dr .Elhadi Mohieldin Awooda

Ph.D Dentistry

Dr .Ali Abdel Rahman Saeed Marouf

Ph.D Laser Physic

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بسم الله الرحمن الرحيم

قال تعالى: (وَلَوْ أَنَّمَا فِي الأَرْضِ مِنْ شَجَرَةٍ أَقْلامٌ وَالْبَحْرُ يَمُدُّهُ مِنْ بَعْدِهِ سَبْعَةُ أَبْحُرٍ مَا نَفِدَتْ كَلِمَاتُ اللَّهِ إِنَّ اللَّهَ عَزِيزٌ حَكِيمٌ**)**

صدق الله العظيم

سورة لقمان(٢٧)

Dedication

To my dear beloved parents,

The candles that glow to shine my way to success

To my darling sisters,

Who did never hesitate to help, support and encourage

To all my wonderful friends,

Who helped me and gave me trust to continue

To all of them, I dedicate this research as a sign of

Thanks, appreciation, respect and love.

Acknowledgements

First of all thanks to ALLAH for giving me the strength and ability to complete this study. After that, I would like to express deep thanks to my supervisors Dr. Elhadi Mohieldin Awooda and Dr. Ali Marouf for their support and supervision. My thanks extended to the staff of Institute of Laser, Sudan University of Science and Technology for their support Thanks goes also to Dr. Abdul Mageed, Dr. Enas and Dr. Mudather for their great help in providing laser devices without whom this work would never be accomplished. Special thanks to the patients participated in this study, voluntary to treat them by laser and conventionally by abrasion technique.

Abstract

Background: Dark or black colored gingiva is an important esthetic concern. Gingival depigmentation procedure is a type of perio plastic surgery where the gingival epithelium is excised with various techniques to lighten the color of the gingiva. The aim of this study was to compare gingival depigmentation procedure with conventional rotary technique and diode laser. **Method:** This comparative clinical trial study was carried out among twelve patients who attended the department of periodontology, Khartoum dental teaching hospital and Dafenshy Dental Clinic complaining of gingival hyperpigmentation. Patients were informed about the treatment modalities and signs informed written consents to participate voluntary. Patients were divided into two groups, group one, treated conventionally first for one jaw and after one week the other jaw was treated by diode laser, while group two treated by laser first and then after one week by conventional methods. Gingival depigmentation was done by diamond bur as conventional method and soft tissue diode laser with 808nm wavelength in continuous mode. The fiber optic tip diameter was 600mm lased with power of 1.5 w. Post operative complication (bleeding ,swelling and infection) , the pain perception by using the (VAS), wound healing ,patients comfort ability and satisfaction had been assessed after both procedures in interval of three hours , three days and one week. **Results:** In this study most of the subjects did not complain of the post operative complications (swelling, infection and bleeding) after diamond bur and diode laser depigmentation. There were Statistical significant difference between VAS in diamond bur group and VAS in diode laser group after 3hours and three days. In gingival depigmentation with diode laser the subjects complained of moderate pain while the site treated with diamond bur abrasion only mild pain was felt, although both sites show decreased in the pain perception by the end of the first week. The gingiva that treated with diode laser shows delayed in the wound healing but despite this most of the subjects was very satisfied by the beautiful pink gingival color in comparison with fair pink with diamond bur abrasion. **Conclusion:** Despite the diode laser depigmentation was associated with delayed wound healing and discomfortable for some subjects; most of the responders were very satisfied about the esthetic results and time preservation with diode laser therapy more than the conventional abrasion method.

المستخلص

الخلفية : زيادة تصبغ لون اللثة يعتبر من الامور الجماليه التي تحتاج لاهتمام وعناية وازالة تصبغ اللثه يعتبر من عمليات اللثه التجميليه والتي يتم فيها ازاله الخلايا الصبغيه بطرق مختلفة و هدف هذه الدراسه هو المقارنه بين ازالة تصبغ اللثة بإحدى الطرق التقليدية وهي مكينة الاسنان الدورانية (دايموند بير) و ليزر اشباه الموصلات .

الطريقة: هذه التجربه الاكليكنية بغرض المقارنه تمت لعدد ١٢ مشارك (متطوع) في قسم اللثة، بمستشفى الأسنان التعليمي / الخرطوم و (مركز دافينشي لطب الأسنان). موافقة خطية مطلع عليها أخذت من كل المشاركين في الدراسة. المرضى تم تقسيمهم لمجموعتين ، المجموعة الأولى تمت معالجتها بالطريقة التقليدية للثة التابعة لأحد الفكين وبعد اسبوع اللثة التابعة للفك الثاني عولجت بالليزر لإزالة التصبغ الزايد. والمجموعة الثانية تمت معالجتها أولاً بالليزر وبعد اسبوع بالطرق التقليدية . وإزالة تصبغ اللثة تم القيام به بالطريقه التقليديه بواسطة ماكينه الأسنان الدورانية (دايموند بير) و ليزر أشباه الموصلات . الطول الموجي ٨٠٨ نانوميتر، القدرة ١.٥ واط ، قطر الحافه لليف البصري ٦٠٠ مايكروميتر، وهذا الليزر يعمل بنمط مستمر وتلامس مباشر مع اللثة. بعد عملية إزالة تصبغات اللثة يتم تحديد المشاكل ومضاعفات بعد العملية . والادراك الحسي للالم يتم قياسه عن طريق (VAS) (المقياس المتماثل المرئي) ويتم قياس مستوى التئام الجروح و مدى رضى المشاركين في هذه الدراسة عن النتائج المصاحبة لها وكل ذلك يتم بعد ثلاث ساعات، ثلاث يوم و اسبوع منذ بداية العلاج .

النتائج: في هذه الدراسه لم يعاني معظم المشاركين فيها من مشاكل ومضاعفات بعد العمليه (التورم، النزيف، والالتهاب) بعد ازالة التصبغ بكلتا الطريقتين. قياس الالم بالمقياس المتماثل المرئي (VAS) يظهر نتيجة ذات اهميه احصائيه عند مقارنه كل العمليتين لازالة تصبغات اللثة و ذلك بعد ثلاثه ساعات وثلاثه ايام. في حاله ازاله تصبغ اللثة بالليزر لوحظ شكوى المشاركين من الم متوسط بينما كان الالم بسيط بالنسبه لازالة التصبغ بالطريقة التقليدية وفي كلا الحالتين يتناقص الالم بنهايه الاسبوع الاول. اللثة المعالجة بالليزر تظهر تاخر في بريان اللثة و لكن بالرغم من ذلك معظم المشاركين في الدراسه كانوا راضين ومقتنعين جدا بالنتيجة الجماليه ولون اللثة الوردي الجميل بعد معالجه التصبغ بالليزر . الختام : بالرغم من ان علاج تصبغ اللثة بالديود ليزر (ليزر اشباه الموصلات) يصاحبه تاخر بريان و عدم ارتياح بعض المشاركين نتيجه للالم المتوسط الذي يصاحبه، الا ان معظم المشاركين كانوا ذو اكتفاء عالي بالنتيجه الجماليه والمحافظه علي الزمن المصاحب للعلاج بالليزر وذلك مقارنه بالطريقه التقليدية. الديود ليزر يعتبر طريقه فعاله، ممكنه و متقبله من المرضى لعلاج زيادة تصبغ اللثة.

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List of Abbreviations

VAS (visual Analog Scale)

μm	micrometer
W	Watts (power)
nm	nanometer
CW	Continuous wave
Hz	Hertz

CHAPTER ONE

Introduction

1.1 Background

A smile is an expression denoting pleasure, sociability, and happiness and can reflect self-confidence of an individual. A smile seems to have a favorable influence upon others and makes one likeable and more approachable. The beauty of a smile is not only influenced by how the teeth and lips look, but also by the way gingival tissue appears. A dark or black colored gum is one of the concerns of patients reporting to dental clinics (Suragimath et al., 2016).

Gingival hyper pigmentation is increased pigmentation beyond the normally expected degree of the oral mucosa. Several physiologic and/or pathologic factors can cause hyper pigmentation**.** However the most common cause is physiologic or ethnic hyper pigmentation (Hegde et al., 2013).

Physiologic hyper pigmentation is genetically determined and is clinically manifested as variable amounts of diffuse or multifocal melanin pigmentation in different ethnic group (Hegde et al., 2013).

Melanin is a non-hemoglobin brownish pigment and it is the most common endogenous pigment, synthesized by the melanocytes in the basal and supra basal layer of the epithelium. Gingival hyper pigmentation occurs due to excessive accumulation of melanin in these layers. Although melanin hyper pigmentation of gingiva is completely benign and does not cause any problem clinically, patients especially the gummy smile individuals often complain of compromised esthetics (Khalilian et al., 2016).

High levels of oral pigmentation are usually observed in those of African, East Asian, India or Hispanic ethnicity (Rosa et al., 2007) .The severity of pigmentation varies from one individual to another, based on melanoblastic activity (Sagar et al., 2016).
Demand for cosmetic therapy of gingival melanin pigmentation is common. Gingival de pigmentation can be considered as periodontal plastic procedure where by the gingival

hyper pigmentation is removed by various techniques, and the technique selection should primarily based on clinical experiences and individual preferences with primary indication on demand for improved esthetics (Murthy et al., 2012).

The effective elimination of such melanotic areas was attempted by variable means such as scalpel surgery, abrasion with diamond burs, cryosurgery, electro surgery, chemical methods including acoustic agents 90% phenol and 95% alcohol (not used nowadays) and method aimed to masking the pigmented gingival tissue from less pigmented gingival areas (free gingival graft and a cellular dermal matrix allograft) (Murthy et al., 2012).

Laser also had been used in gingival de pigmentation such as:

Nd: YAG, Semiconductor diode laser, CO_2 laser and Argon laser (Murthy et al., 2012).

1.2 Research Problem

The gingival hyper pigmentation may lead to psychological and social problems among African females such as Sudanese women's , epically when it become visible during smiling ,so they seek for aesthetic smile by looking in many ways of plastic therapy (Gluckman & Torit 2016). Gingival hyperpigmentation could be treated by different methods, in this study we tries to solve this problem by two modalities of treatment for gingival depigmentation (bur abrasion and diode laser 808 nm soft tissue laser).

1.3 Justification

As a result of increasing esthetic demand among Sudanese females and because gingival color and appearance are essential components for attractive smile, removal of unsightly pigmented gingiva is the need for a pleasant and confident smile. Accordingly, there is a need to demonstrate two method of gingival melanin de pigmentation (Gingival abrasion technique using diamond bur and diode laser).

1.4 Objectives

1.4.1 General Objective

To compare the effectiveness of diode laser (808nm) in gingival de pigmentation with one of the conventional methods, gingival abrasion technique using diamond bur.

1.4.2 Specific Objectives

i. To measure the pain by using VAS (Visual Analog Scale) on the sites operated with bur abrasion and the site treated with diode laser.
ii. To assess bleeding, swelling and infection (complication) after treatment.
iii. To assess the wound healing by using the wound healing score.
iv. To assess the Patient's acceptance (satisfaction) by using simple satisfaction scale.
v. To assess the patient comfort ability regarding these treatment.
vi. To assess the improvement in aesthetic (cosmetic) appearance by photograph.

1.5 Literature Review

1.5.1 Gingival Depigmentation

Smile is an expression of happiness, self-confidence, kindness and beauty. Along with teeth and lips, gingiva is also a vital component of smile. Gingival hyper pigmentation may result in psychological distress especially when the appearance is importance for the individuals.

Gingival pigmentation is well documented in literature and is considered to be multi factorial, whether physiological or pathological.

Gingival melanin hyper pigmentation is seen as a genetic trait in some population and termed as physiologic or racial gingival pigmentation. It has been suggested that although pigmentation under normal conditions is genetically determined, its distribution in the mouth may be the result of secondary influences and environmental factor (Sagar et al., 2016).

The degree of melanin pigmentation depends on the number and distribution of melanocytes and their capacity to transfer melanin, and melanin uptake by keratinocytes. Melanin-pigmented gingiva is often a demand for depigmentation mainly for esthetic reasons and the elimination of these melanotic areas is done through surgery or lasers (Feller et al., 2014).

One of the most common surgical techniques for gingival depigmentation is the using of diamond bur for surgical abrasion to remove the gingival epithelium that contains the melanin pigment.

I. Gingival abrasion technique using diamond bur

It is simple, safe and non-aggressive method that can be easily performed and readily repeated, if necessary to eradicate any residual regimentation. Also, these techniques do not require any sophisticated equipment and are hence economical. Diamond bur in high speed hand piece can be used in brushing stroke action with minimal pressure for removal of superficial epithelium and care should be taken to control the speed and pressure of the hand piece bur so as not to cause unwanted pitting of the under lying tissue. Minimum pressure with copious saline irrigation should be used without holding

the bur in one place to perceive excellent results (Farid et al., 2017).

A case series study that had been done by Kathariya and Pradeep in India in 2011 with a sex patients shows that bur abrasion is as effect as scalpel in gingival depigmentation with no post operative pain, hemorrhage and infection ,healing was un eventual (Kathariya , Pradeep , 2011).

II. Gingival ablation using laser technique

Laser ablation has been recognized as one of the most effective, pleasant, reliable and a minimally invasive treatment option for treatment of gingival melanin hyper pigmentation.

Different lasers have been used for gingival depigmentation, including carbon dioxide (CO_2; 10600 nm), diode (808 -980nm), neodymium-doped: yttrium, aluminum, and garnet (Nd: YAG; 1064 nm), erbium-doped (Er-YAG; 2940 nm), and erbium- and chromium-doped: yttrium, scandium, gallium, garnet (Er,Cr:YSGG; 2780 nm) lasers (Zingade et al ., 2012).

Advantages of lasers versus conventional surgery include: easy handling, hemostasis, lesser operative time, decreased swelling, scarring, post and intra operative pain, decontamination and sterilization effects are good, elimination of using periodontal dressing and increased patient acceptance (Boyapati, 2017).

The laser surgery does has a number of disadvantages like: delayed inflammatory reactions that can occur with mild post-operative discomfort lasting for 1-2 weeks. In addition, the use of sophisticated equipment makes the treatment quite expensive. A loss of tactile sensitivity can also occur when using lasers (Kathariya, Pradeep, 2011).

The CO_2 lasers are used for depigmentation procedure but they can damage tooth structure, and the delivery system is very cumbersome, also Er-YAG; may used for this procedure but it is very expensive. Diode is a soft tissue laser, the wavelengths of diode laser are highly absorbed by pigmented tissue and it is small in size, not expensive and not causes damage to the surrounding tissue, so it considered as an excellent laser for used in gingival depigmentation (Sagar et al., 2016).

III. Semiconductor diode laser

The use of semiconductor diode laser for depigmentation procedure was introduced by Yousuf et al (Yousuf et al., 2000).

Diode lasers (808-980 nm range) emit laser light in the near infra-red spectrum of the electromagnetic radiation which are highly absorbed in hemoglobin and melanin.

A diode laser is a solid-state semiconductor laser that typically uses a combination of Gallium (Ga), Arsenide (Ar), and other elements, such as Aluminium (Al) and Indium (In), to change electrical energy into light energy. It is usually operated in contact mode to allowing good tactile sensation and precision while operating using a flexible fiber optic delivery system, and emits laser in continuous- wave or gated pulsed modes. The power output for dental use is generally around 2 to 10 watts and for gingival depigmentation, 1 to 3 watts are recommended for gingival ablation (Prabhuji et al., 2011).

The diode laser exhibit thermal effect using the "hot-tip", the effect caused by heat accumulation at the end of the fiber and produces a relatively thick coagulation layer on the treated surface. The usage is quite similar to electro cauterization.

As the tissue penetration of a diode lasers is minimal, it does not produce any deleterious effect on the root surface. The usual mechanism of diode laser that lead to ablation or decomposition of biological materials is photochemical, thermal, or plasma mediated (Sagar et al., 2016).

Thermal ablation means that the energy delivered by the laser interacts with irradiated material by an absorption process, yielding a temperature rise.

As the temperature increases at the surgical site, the soft tissue is subjected to warming (37–60°C), protein denaturation, and coagulation (> 60°C). The rapid rise in intracellular temperature and pressure leads to cellular rupture as well as release of vapors and cellular debris termed the laser plume; it creates locally sterile condition, resulting in a reduction of bacteremia (Sagar et al ., 2016).

The diode laser causes minimal damage to the periosteum and bone under the gingiva being treated, and it has the unique property of being able to remove a thin layer of epithelium, and a sterile inflammatory reaction occurs after lasering. Blood vessels in the

surrounding tissue up to a diameter of 0.5 mm are sealed thus, the primary advantages of diode laser are homeostasis and a relatively dry operating field (Sagar et al., 2016).

Small blood and lymphatic vessels are sealed due to the generated heat, thereby reducing or eliminating bleeding and edema. Denatured proteins within tissue and plasma are the source of the layer termed "coagulum", which is formed because of laser action and serves to protect the wound from bacterial or frictional action. Also the diode laser did not produce any deleterious effect on the root surface. Therefore, diode laser surgery can be performed safely in close proximity to dental hard tissue (Govila et al., 2011).

In case of gingival depigmentation by diode laser .After application of topical anesthesia and before using laser some precaution should be given like safety glasses that were worn by operating assistance and patient, reflected mirror surface were avoided and avoid using laser in the presence of explosive gases. Depigmentation should be done with light brushing strokes and the tip kept in motion all the time. Remnants of the ablated tissue were removed using sterile gauze dampened with saline solution. This procedure was repeated until the desired depth of tissue removal was achieved (A patel et al., 2015).

Pain reduction after using lasers may be due to the protein coagulum formed on the wound surface that seals off sensory nerve endings and it also acts as a biologic dressing (Zingade et al., 2012).

A Clinical trial study that had been done by Mahitab Soliman et al in india in 2014 for twenty patients complaining of unsightly hyper pigmented areas in their gingiva. A soft tissue diode surgical laser unit, delivered by a 400-μm diameter fiber wavelength 808nm ± 5, power 1–2 W was used for de pigmentation of the maxillary and mandibular anterior gingiva and buccal mucosa . At the third week postoperatively, restoration of the normal gingival and mucosal texture and color was achieved with optimal esthetic results. Most of the patients (18 patients) had no postoperative discomfort including: pain, edema and disfigurement (Silliman et al., 2014).

Another case series study for the treatment of gingival hyper pigmentation with rotary abrasive, scalpel, and laser techniques had been done by Murthy et al in India in 2012 for three patients. Compared to scalpel blade and rotary abrasion, depigmentation, with diode laser (810 nm, A 400 μm fiber optic tip and power

setting of 1.5 watt) showed delayed healing. At the VAS evaluation sites operated on with scalpel blade and bur abrasion, the patients complained of moderate pain, but at the site treated with diode laser, only slight or no pain was recorded. Better results of de pigmentation were achieved with diode laser than conventional scalpel and with rotary abrasion with respect to esthetics. The results point out that lasers are an effective and a safe means to removal of hyper pigmentation from the gingiva (Murthy et al., 2012).

In 2011, Gupta reported the results of gingival depigmentation with diode laser (wavelength 980 nm, power 2-4 W). He reported complete healing at one month and normal pink color of gingiva in the treated area. No infection, pain or hemorrhage was reported post-operatively. At 15-months follow up, no recurrence was noted (Gupta, 2011).

A Clinical trial study that had been done by El shenawy et al in Cairo University, Egypt in 2015 for 15 patients who requested cosmetic therapy for melanin pigmented gums. The laser beam delivered by fiber optic with a diameter of 320 µm, the diode laser system has 980 nm wavelengths and 3 W irradiation powers, in a continuous contact mode in all cases, the entire surface of each pigmented maxillary and mandibular gingiva that required treatment was irradiated in a single session. Clinical examination and digital image analysis were done and the patients were followed up for three successive months. There was a statistically significant change in prevalence of bleeding after treatment, as none of the cases showed any signs of bleeding one week, one month and three months after ablation. No statistically significant change was observed in the prevalence of swelling after treatment .The VAS evaluation demonstrated that only four patients complained of mild pain immediately after the procedure.

No pain was perceived from the patients in the rest of the follow up period. There was no statistically significant change in prevalence of pain immediately after treatment compared to pain during treatment. There was a decrease in cases with mild pain after 1 week, 1 month as well as 3 months compared to pain during treatment and immediately after treatment. Within the limitations of this study, the use of diode laser was shown to be a safe and effective treatment modality that

provides optimal aesthetics with minimal discomfort in patients with gingival hyper pigmentation (El Shenawy et al., 2015).

Four cases report study was carried out by reddy et al to assess the esthetic management of melanin hyper pigmentation using diode laser (with wavelength of 970 nm ,power 2.5 to 3 w for two cases and 810 nm wavelength with power 1 to 1.2 w for another two patents) ,the diode laser was used for depigmentation of the maxillary and mandibular anterior gingiva up to the distal aspect of the first premolar on the both sides .The patients were reviewed after one week , healing was uneventful in all the cases without any post surgical complication ,at the one month follow up visit the gingiva appear healthy pink and firm and with the patients expressing satisfaction about the significantly improved esthetic results (Reddy et al., 2015).

Gingival health and appearance are essential components for an attractive smile, and removal of unsightly pigmented gingiva is the need for a pleasant and confident smile.

CHAPTER TWO

Basic Concepts

2.1 Laser

The term LASER *s*tands for Light Amplification by Stimulated Emission of Radiation. A beam of light is composed of individual packets of energy that are called quanta or photons.

Each of these photons has a particular energy and direction of travel. The energy of a quantum of light is proportional to its frequency, i.e; it is reciprocal of its wavelength. In the presence of a properly prepared laser material, it is possible for a quantum of light to trigger the release of other quanta with the same wavelength and direction of travel. This phenomenon is called stimulated emission, and it is an essential element in lasing.

Stimulated emission requires inversion of population between two energy levels, his process of stimulated emission enables light amplification, which can result in lasing.

2.1.1 Properties of Laser Beams

The most characteristic properties of laser beams are (i) monochromaticity, (ii) coherence (spatial and temporal), (iii) directionality, (iv) brightness.

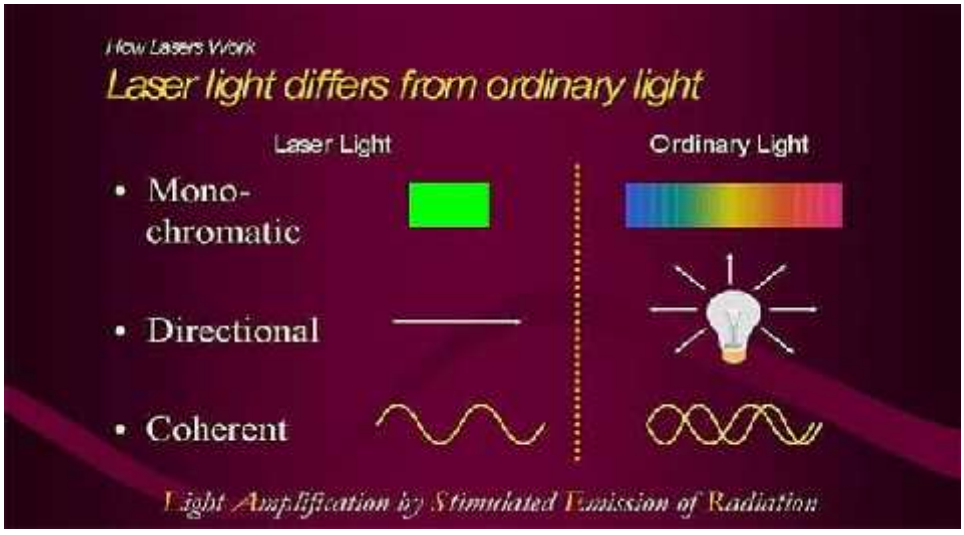

Figure 2.1 Properties of laser light

i. Monochromaticity

Waves of light with single frequency ν of vibration or single wave-length λ are termed as single color or monochromatic light source.

ii. Directionality

One of the most striking properties of laser is its directionality, that is, its output is in the form of an almost parallel beam.

iii. Coherence

All the waves in the laser beam remain spatially and temporarily in the same phase. Photons generated through stimulated emission are in phase with the stimulating photons.

iv. Brightness

Lasers are more intense and brighter sources compared to other conventional sources such as the sun (Singh et al., 2012).

2.1.2 Elements of Laser

A laser is generally composed of three basic elements:

I. A material that can store energy to be released by stimulated emission.
II. A means of replenishing the energy stored in the excited laser material .
III. An optical resonator (cavity) for retaining a fraction of the light emitted by the lasing material to stimulate further emission (Palanker, 2013).

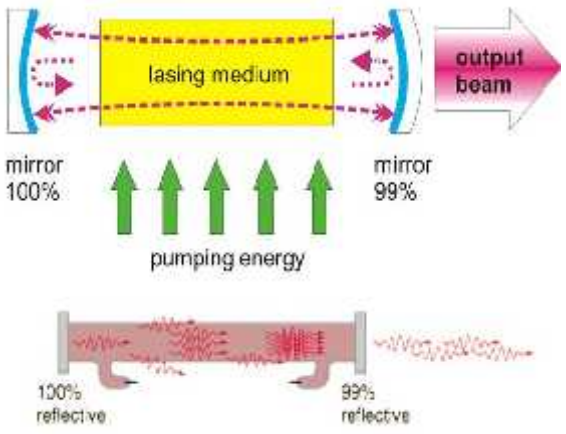

Figure 2.2 Elements of Laser

The lasing (or gain) medium can be a gas, liquid, or solid. Lasers can be pumped by continuous discharge lamps and by pulsed flash lamps, by electric discharges in the laser medium, by chemical reactions, by an electron beam, by direct conversion of electric current into photons in semiconductors, or by light from other lasers. Laser pulse durations can vary from femtoseconds to infinity (continuous) (Palanker, 2013).

2.1.3 Laser Classification:

Lasers may be classified according to the type of active medium, region of emitted wavelength or mode of operation

I. . According to the active medium, lasers are classified to : solid, gas, liquid and semiconductor lasers

Solid state lasers: Ruby laser (chromium doped), Nd: YAG and Nd: Glass laser, Alexandrite laser

Semiconductor –Gallium Arsenide laser

Liquid laser: Dye laser (solution of organic compound)

Gas lasers:

Atom: He-Ne (Helium –Neon), He-Cd (Helium –Cadmium)

Molecule: CO_2 (Carbon Dioxide). N2 (Nitrogen)

Ion: Ar+ (Argon ion), (Krypton ion)

Metal vapor laser: Cu (Copper) vapor, Au (Gold) Vapor

Special laser: X ray laser

Chemical laser: HF laser

Eximer laser

Fiber hosted laser: Erbium and Yttrium ions in double clad form.

Free electron lasers

II. According to the spectral region of the emitted laser, the classification is: Ultra Violet UV, visible and Infra Red I.R lasers.
III. Based on the mode of operation lasers are classified to: continuous wave (CW), chopped, pulsed and ultra short pulsed lasers (by using the technique of Q switching, mode locking (Nitish et al., 2011).

2.1.4 Mechanism of laser action

Laser light is a monochromatic light and consists of a single wavelength of light. It consists of three principal parts: An energy source, an active lasing medium, and two or more mirrors that form an optical cavity or resonator. For amplification to occur, energy is supplied to the laser system by a pumping mechanism, such as, a flash-lamp strobe device, an electrical current, or an electrical coil. This energy is pumped into an active medium contained within an optical resonator, producing a spontaneous emission of photons. Subsequently, amplification by stimulated emission takes place as the photons are reflected back and forth through the medium by the highly reflective surfaces of the optical resonator, prior to their exit from the cavity via the output coupler. In dental lasers, the laser light is delivered from the laser to the target tissue via a fiber optic cable, hollow waveguide, or articulated arm .Focusing lenses, a cooling system, and other controls complete the system. The wavelength and other properties of the laser are determined primarily by the composition of an active medium, which can be a gas, a crystal, or a solid-state semiconductor (Verma, 2012).

As its first application in dentistry by Miaman, in 1960, the laser has seen various hard and soft tissue applications. In hard tissue application, the laser is used for caries prevention, bleaching, restorative removal and curing, cavity preparation, dentinal hypersensitivity, growth modulation and for diagnostic purposes, whereas

soft tissue application includes wound healing, removal of hyperplastic tissue to uncovering of impacted or partially erupted tooth, photodynamic therapy for malignancies, photostimulation of herpetic lesion. Gingivectomy,frenectomy ,gingival melanin depigmentation and heamostasis , Use of the laser proved to be an effective tool to increase efficiency, specificity, ease and comfort of the dental treatment (Verma, 2012).

The hard lasers, such as, Carbon dioxide (CO_2), Neodymium Yttrium Aluminum Garnet (Nd: YAG), and Er:YAG, which offer both hard tissue and soft tissue applications, have limitations due to high costs and a potential for thermal injury to tooth pulp, whereas, on the other hand in cold or soft lasers, based on the semiconductor diode devices, which are compact, low-cost devices used predominantly for applications (Verma, 2012) .

2.1.5 Laser Tissue Interaction

The light energy produced by a laser can have four different interactions with a target tissue: Reflection, Transmission, Scattering, and Absorption.

When a laser is absorbed, it elevates the temperature and produces photochemical effects depending on the water content of the tissues. When a temperature of 100°C is reached, vaporization of the water within the tissue occurs, a process called ablation. At temperatures below 100°C, but above approximately 60°C, proteins begin to denature, without vaporization of the underlying tissue. Conversely, at temperatures above 200°C, the tissue is dehydrated and then burned, resulting in an undesirable effect called carbonization.

Absorption requires an absorber of light, termed chromophores**,** which have a certain affinity for specific wavelengths of light. The primary chromophores in the intraoral soft tissue are Melanin, Hemoglobin, and Water, and in dental hard tissues, Water and Hydroxyapatite. Different laser wavelengths have different absorption coefficients with respect to these primary tissue components, making the laser selection procedure-dependent (Carroll, Humphreys, 2006).

2.1.6 Laser Safety

While most dental lasers are relatively simple to use, certain precautions should be taken to ensure their safe and effective operation. First and foremost is protective eyewear by anyone in the vicinity of the laser, while it is in use. This includes the doctor, chair side assistants, patient, and any observers such as family or friends. It is critical that all protective eyewear worn is wavelength-specific.

Accidental exposure to the non-target tissue can be prevented through the use of warning signs posted outside the nominal hazard zone, limiting access to the surgical environment, minimizing the reflective surfaces, and ensuring that the laser is in good working order, with all manufacturer safeguards in place. With regard to prevention of possible exposure to infectious pathogens, high volume suction should be used to evacuate any vapor plume created during tissue ablation, and normal infection protocols should be followed. Each office should have a designated Laser Safety Officer to supervise the proper use of the laser, coordinate staff training, oversee the use of protective eyewear, and be familiar with the pertinent regulations (Parker, 2007).

CHAPTER THREE

Materials and Methods

3.1 Study Design

Clinical trial study (experimental).

3.2 Study Area

Khartoum dental teaching hospital and Dafenshy Dental Clinic.

3.3 Study Duration

This study started since January to march 2018.

3.4 Study Population

Females with gingival melanin hyper pigmentation that match the inclusion criteria were included in the study population.

3.4.1 Inclusion Criteria

I. Willingness of the patients to participate in the study.
II. Age group (above 18 years old).
III. Free from any clinical symptom and sign of gingival and periodontal diseases

3.4.2 Exclusion Criteria

I. Subjects with habits of smoking
II. Pregnancy
III. Take medication that may change the color and size of the gingival tissue
IV. Systemic disease that lead to gingival hyper pigmentation e.g. Addison disease

3.5. Sampling

3.5.1 Sample Technique

Convenience sampling

3.5.2 Sample Size: (12 subjects) were setting for gingival depigmentation during the study duration.

3.6 Variables

3.6.1 Dependant Gingival depigmentation

3.6 .2 In dependant

I. Type of the procedures **(** diode laser ablation , abrasion by diamond bur **)**
II. Upper or lower jaw

3.7 Data Collection Methods and Tools

I. Check list (Appendix 1)
II. Clinical procedures

This study was done in 12 females with gingival melanin hyper pigmentation. The degree of gingival pigmentation was determined before and after treatment by use the Melanin pigmentation index (Takashi et al., 2005)

Melanin pigmentation index

The degree of melanin pigmentation was determined by melanin pigmentation index based on the following scoring system:

Score 0: No pigmentation.

Score 1: Solitary unit(s) of pigmentation in papillary gingiva without extension between neighboring solitary units.

Score 2: Formation of continuous ribbon extending from neighboring solitary units.

The subjects who fulfill the inclusion criteria will include in this study for depigment their gingival tissue by using one of the conventional methods which is abrasion by high speed rotary instrument, diamond bur (round end taper fissure bur) in the lower anterior labial gingival tissue and by diode laser for gingival ablations in the upper anterior labial gingival tissue, this was done for half of the subjects and

for the other half we did the depigmentation by laser technique for the lower labial gingival tissue and the abrasion by diamond bur was done for the upper labial gingiva (from the right second premolar to the left second premolar).

In the gingival gepigmentation by the diode laser, the laser parameters are:

Laser wavelength: 808 nm

Laser Power: 1.5 W

Fiber optic diameter: 600-µm

(der elexxion pico – a dental laser (made in Germany that combines mobility and professionalism)) .It is class 4 dental laser, 230 V/50 Hz/60Hz power supply ,wavelength :808 +-10 nm ,max.pulse output: 5 W ,max.average out put 2.5w, maxpulse rate cw-20,000Hz , pulse duration :26 ms /CW).

The procedure was done for both jaw and certain assessment may be done like:

Clinical Assessment of swelling, bleeding and infection (abscess, acute inflammation) should be performing three hours from termination of the procedures, after three days and after one week.

I. Clinical evaluation of bleeding

Bleeding scores: A = none; B = Slight; C = Moderate; D = Severe **(**Ishii et al., 2002**)**.

II. The Visual analog scale (VAS)

The VAS was used to measure the intensity of pain experienced after treatment. The VAS consisted of a horizontal line 100 mm long, anchored at the left end by the descriptor ‘‘no pain’’ and at the right end by un tolerable pain. The patient placed a mark to coincide with the level of pain. The distance of this point, in millimeters, from the left end of the scale was recorded and used as the VAS score. Scores were calculated as: 0 =no pain; 0.1 to 3.0 cm (1 to 30 mm) = mild pain; 3.1 to 6.0 cm (31 to 60 mm) = moderate pain; 6.1to 10 cm (61 to 100 mm) = severe pain (Huskisson, 1982).

Patient perception regarding therapy

To evaluate patient's perceptions about the therapy/ three hours after the ending of surgical procedure, the patients received a check list that demonstrated their perception of possible discomfort/pain during the treatment. Based on a 100-mm horizontal line (visual analog scale; VAS), the patient marked their responses, indicating their degree of pain/discomfort perceived on each side separately. Three days after surgery, the patients were instructed to respond, based on the VAS scale about their perception of the intensity of pain and at the end of the first week post operatively for each side separately.

III. Wound healing was evaluated by certain score that show the degree of tissue epithelialization and healing with or without ulcer and necrosis following the surgical procedure (Grover et al., 2014).

IV. Patient satisfaction

The level of satisfaction obtained with each therapeutic modality was evaluated using a simplified scale by selecting one of the following choices: very satisfied, satisfied, neutral, moderately satisfied, unsatisfied (Wismeyer et al., 1995).

v. Professional evaluation of cosmetic outcomes

To assess the improvements in esthetic appearance on each side separately.

Images were documented with high-quality photographs taken at the time of surgery (preoperative), immediately after the procedures, after three day (with diode laser ablation), after one week and one month after the surgical procedure. Both preoperative and corresponding postoperative images were compared for evaluation of esthetic outcomes.

3.8 Statistical analysis

The statistical software SPSS version 23m was used for the analysis

The VAS was tested by the chi square test and the other qualitative data also were tested with chi square test .Confidence level of 95 % and P value of 0.05.

3.9 Ethical Consideration

Patients were participate voluntary and they signed informed written consent .The study was approved by the ethical committee from institute of laser.

CHAPTER FOUR

Results and Discussion

4.1 Results

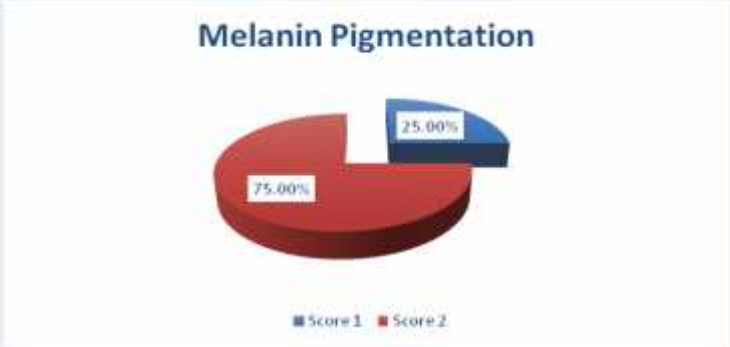

Figure 4.1: The degree of melanin pigmentation

The chart shows that 75% of the subjects had melanin pigmentation score 2

Table 4.1: The post operative complication after gingival de pigmentation in the diamond bur group and diode laser group

Grouping	**No N (%)**		**Slight N (%)**		**Moderate N (%)**	
Swelling	Diode laser	Diamond bur	Diode laser	Diamond bur	Diode laser	Diamond bur
After 3 Hours	10(83.3%)	12 (100 %)	2(16.7%)	0 (0)	0 (0)	0 (0)
After 3 Days	11(91.7%)	11 (91.7%)	1 (8.3 %)	1 (8.3 %)	0 (0)	0 (0)
After 1 Week	12 (100%)	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Infection						
After 3 Hours	12 (100%)	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)
After 3 Days	12 (100%)	11 (91.7)	0 (0)	1 (8.3)	0 (0)	0 (0)
After 1 Week	12 (100%)	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)
Bleeding						
After 3 Hours	11(91.7%)	12 (100)	1(9.1 %)	0 (0)	0 (0)	0 (0)
After 3 Days	11(91.7%)	12 (100)	1 (8.3 %)	0 (0)	0 (0)	0 (0)
After 1 Week	12 (100%)	12 (100)	0 (0)	0 (0)	0 (0)	0 (0)

The table shows that most of the subjects did not complain of the post operative complications (swelling, infection and bleeding) after three hours, three days and one week respectively.

Table 4.2: Intragroup comparison between VAS at different time interval for diamond bur group

Time		VAS				P Value
		No pain	Mild	Moderate	Severe	
After 3 Hours	Count	4	5	2	1	
	%	33.3%	41.7%	16.7%	8.3%	
After 3 Days	Count	7	4	1	0	
	%	58.3%	33.3%	8.3%	0.0%	0.001*
After 1 week	Count	11	1	0	0	
	%	91.7%	8.3%	0.0%	0.0%	

This table shows that there is Statistical significant difference for VAS between different time intervals in diamond bur group at significant level 0.05.

In this table 41.7% of the participants were had mild pain after three hours from the gingival depigmentation by diamond bur ,58.3 % of the participants came without pain after three days and finally the percentage reached to 91.7% of the participants who came without any pain at the end of the first week.

Table 4.3: Intragroup comparison between VAS at different time interval for diode laser group

Time		VAS				P Value
		No pain	Mild	Moderate	Severe	
After 3 Hours	Count	0	2	8	2	
	%	0.0%	16.7%	66.7%	16.7%	
After 3 Days	Count	2	7	3	0	
	%	16.7%	58.3%	25.0%	0.0%	0.00٠*
After 1 week	Count	9	3	0	0	
	%	75.0%	25.0%	0.0%	0.0%	

This table shows that there is Statistical significant difference for VAS between different time intervals in diode laser group at significant level 0.05.

In this table 66.7% of the participants were had moderate pain after three hours from the gingival depigmentation by diode laser, 58.3 % of the participants came with mild pain after three days and finally the percentage reached to 75.0% of the participants who came without any pain at the end of the first week.

Table 4.4: Wound healing following gingival de pigmentation in diamond bur group

Wound healing	A(complete epithelization) (N - %)	B (Incomplete epithelization) (N - %)	C (Ulcer) (N- %)
After 1 Week	10(83.3 %)	2(16.7)	0(0)
After 2 Week	12 (100)	(0) 0	0 (0)
After 3 Week	12 (100)	0 (0)	0 (0)

This table shows that 10 (83.3%) of subjects healed with complete epithelization of the gingival tissue after one week and all the subjects show complete healing by the end of the second week .

Figure 4.2: The Patient satisfaction after gingival de pigmentation with diamond bur

The chart shows that 58.30% of the subjects were very satisfied by the esthetic results.

Table 4.5: Wound healing following gingival de pigmentation in diode laser group

Wound healing	A (complete epithelization) (N - %)	B (Incomplete epithelization) (N - %)	C (Ulcer) (N-%)
After 3 Days	0 (0)	10 (83.3%)	2(16.7%)
After 1 Week	1(8.3%)	10(83.4%)	1 (8.3%)
After 2 Week	9 (75%)	3 (25%)	0 (0)
After 3 Week	12(100%)	0 (0)	0 (0)

This table shows that 10 (83.3%) of the subjects healed with in complete epithelization of the gingival tissue after three days, 10(83.4 %) of the subjects healed with in complete epithelization of the gingival tissue after one week and 9 (75%) of the subjects healed with complete epithelization of the gingival tissue after two weeks and all the subjects show complete healing by the end of the third week.

Figure 4.3: The Patient satisfaction after gingival de pigmentation with diode Laser

The chart shows that 75.00 % of the subjects were very satisfied by the esthetic results.

Table 4.6: Intergroup Comparison between VAS for diamond bur and VAS for diode Laser

Time	Group	VAS				P value
		No pain	Mild	Moderate	Severe	
After 3 Hours	Diamond bur (count) %	4 33.3%	5 41.7%	2 16.7%	1 8.3%	0.048*
	Diode Laser (count) %	0 0.0%	2 16.7%	8 66.7%	2 16.7%	
After 3 Day	Diamond bur (count) %	7 58.3%	4 33.3%	1 8.3%	-----	0.033
	Diode Laser (count) %	2 16.7%	7 58.3%	3 25.0%	------	
After 1 Week	Diamond bur (count) %	11 91.7%	1 8.3%	-------	------	0.29
	Diode Laser (count) %	9 75.0%	3 25.0%	--------	-------	

This table shows that there is Statistical significant difference between VAS in diamond group and VAS in diode laser after three hours and three days at significant level 0.05.

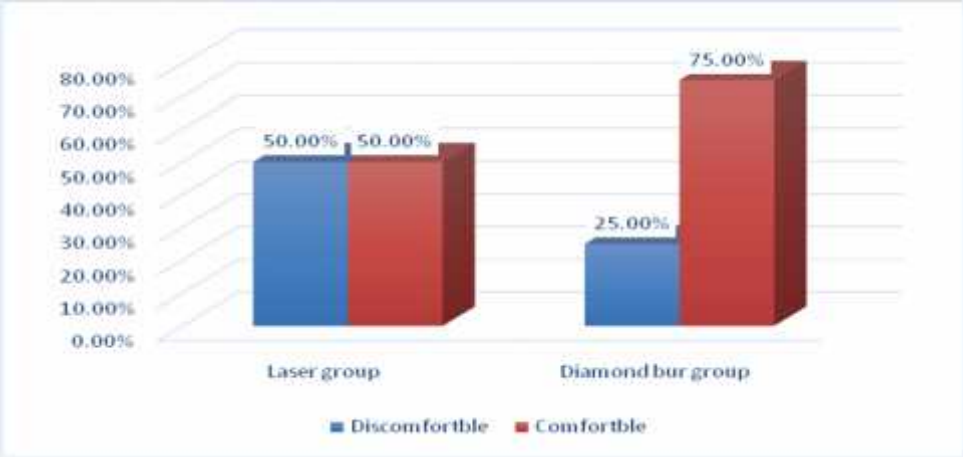

Figure4. 4: The Patient comfort ability after gingival de pigmentation with diode Laser and diamond bur group

The chart shows that 75.00 % of the subjects were comfortable with diamond bur de pigmentation, while just 50% were comfortable with diode laser therapy.

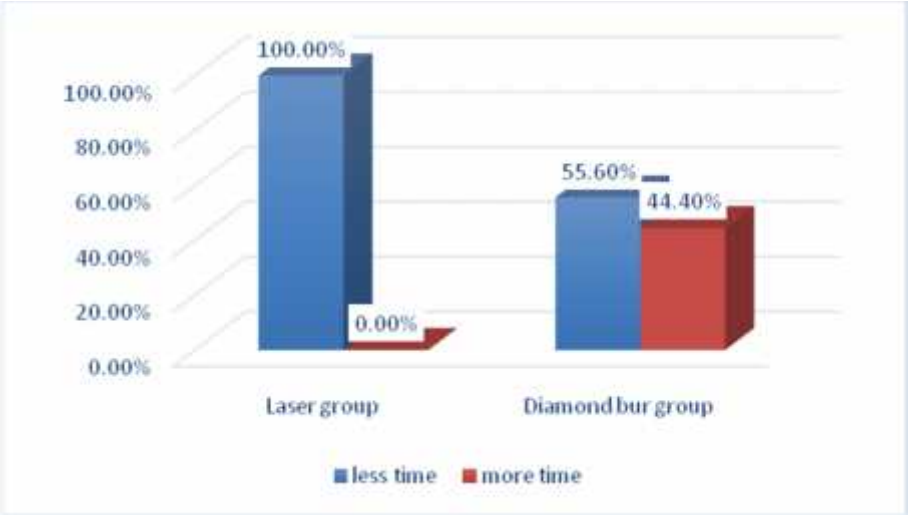

Figure4.5: The patient's perception about the time taken by the depigmentation procedure.

The chart shows that all the subjects think that the laser therapy was time preserving, while 55.60% of them when asked about diamond bur said that it is not consume the time.

4.2 Discussion

The harmony of smile is determined not only by the shape, the position and the color of the teeth but also by the gingival tissue.

Gingival health and appearance are essential components for an attractive smile, and removal of unsightly pigmented gingiva is the need for a pleasant and confident smile (Doshi, 2012).

Gingival hyper pigmentation does not present as a medical problem but complaints of black gum and a demand for depigmentation is common. Many techniques have been tried for depigmentation (El shenawy, 2015).

In this comparative clinical trial study gingival depigmentation was done for twelve subjects, after they were informed about the nature of the procedures and signed the consent, two modalities of treatment including gingival abrasion by diamond bur and ablation by semiconductor diode laser (808nm) had been used.

In this study the gingival depigmentation with diamond bur was not associated with swelling, infection and bleeding in the majority of participants and this may be due to precise and careful used for this technique to avoid any damage to underlying periosteum that may lead to post operative complication, and also due to the protective and curative effect of the periodontal dressing (Baghani , Kadkhodazadeh ,2013). Our study disagreed with Murthy et al study in regarding to post operative swelling , bleeding after gingival depigmentation with diamond bur due to the difficulty in controlling the depth of de-epithelization and obtaining an adequate access (Murthy et al., 2012).

In contrast to rotary diamond bur technique , the gingival depigmentation with 808 nm , 1.5 watts diode laser was associated with slight swelling and bleeding that were observed by some patients after three hours and three days from surgery and these inflammatory signs subsided during the whole follow-up periods , but the majority of the patients (91.7%) showed recovery without any complication . The lack of bleeding after laser treatment can be attributed to the property of lasers to coagulate blood and therefore assist in providing a relatively dry surgical field. As laser is absorbed by Hb pigment and it is an excellent haemostatic agent (Singh et al., 2012).

This result was in agreement with Bakutra et al who observe lack of bleeding following gingival depigmentation by soft tissue diode laser (Bakutra et al., 2018).

The slight bleeding observed by some patients after surgery might be due to the laser beam penetrating deeper than required. This was in agreement with Kishore et al 2014 who observed that the bleeding was directly correlated with the depth of ablation (Kishore et al., 2014).

The lack of swelling after laser treatment is in agreement with Khakhar et al who reported complete removal of the gingival epithelium without causing micro vessel dilatation and this possibly related to the direct vasomotor effects and/or deactivation of local pro-inflammatory mediators by the diode laser light that causing micro vessel narrowing (Khakar et al., 2011).

The decrease of post operative infection (abscess and acute inflammation) following diode laser treatment was in agreement with Govila et al , and it is due to tissue surface sterilization and bactericidal effect of laser (Govila et al., 2011).

In this study when assessing post operative pain following gingival depigmentation by diamond bur by the VAS (Visual Analog Scale), the patients complained of mild pain which had reduced considerably one week after the surgery. The pain was because it was a surgical procedure with open wound that healed by secondary intention, but because the sedative effect of the periodontal pack, the pain was mild and quickly subside (Baghani ,Kadkhodazadeh, 2013).This result was in agreement with the study done by lee et al that noticed mild pain following gingival depigmentation with diamond bur (Lee et al., 2011).

When assessing post operative pain by the VAS evaluation on the site treated by diode laser , most of the patients felt of moderate pain which had been reduced to mild one after three days and then disappeared in most of the patients at the end of the first week from the laser ablation. The pain may be due to the carbonization of tissue that can lead to iatrogenic squeal including post operative pain (Flax, 2011). The pain observed three hours after surgery might be attributed to a low threshold of pain in these cases. Most adverse effects and complications of laser treatment can be predicted by understanding that they are mainly due to collateral damage of normal adjacent structures (Khakar et al., 2011).

Intergroup Comparison between pain after diamond bur abrasion and pain following diode Laser shows that at the VAS evaluation site operated on with bur abrasion , the patients complained of mild pain , but at the site treated with diode laser , moderate pain was recorded . However , the pain had been reduced considerably one week after the surgery .This results are not in agreement with the most of studies like the case series study done by Murthy et al that shows only mild or no pain was recorded with diode laser while moderate pain with bur abrasion (Murthy et al., 2012).

With diode laser, less of pain was experienced following treatment due to the formation of protein coagulum on the wound surface, which acts as biologic dressing. In addition, it may be due to the sealing of sensory nerve endings (Bakutra et al., 2017).

In this study healing of laser wounds is slower than healing of diamond bur wounds due to a sterile inflammatory reaction occurs after laser use or it may be due to the thermal effects and carbonization (Bakutra et al., 2017) (Khan et al., 2017).This result was in agreement with D'Arcangelo et al. who concluded that thermal damage around the lased site is responsible for delayed wound healing (D'Arcangelo et al., 2007).

In this study the respondents were very satisfied towards the esthetic results by both groups, but we found increased in the percentage of very satisfaction in the gingival depigmentation with diode laser by (75%), this because successful treatment following laser ablation of hyper-pigmented areas was evident by the complete regeneration resulting in a healthy pink firm appearance. These findings were in agreement with El Shenawy et al study which confirms the successful application of diode laser techniques for esthetic treatment of gingival hyperpigmentation. Photomodulation effects of laser were shown to help in stimulating the fibroblasts, angiogenesis and accelerating the lymphatic flow, which enhances repair, regeneration of the gingival tissue and beautiful esthetic result (El Shenawy et al., 2015).

In this study gingival depigmentaion with diode laser lead to post-operative discomforts more than that associated with diamond bur depigmentation, this result can be due to the delayed type of inflammatory reaction which occurs with mild post-operative discomfort lasting up to 1–2 weeks (Pradeep, Kathariya , 2011).

This result was not in agreement with study that had been done by Suragimath et all who conclude that diode laser depigmentation procedure is safe and effective, with a better patient and operator comfort (Suragimath et al., 2016).

The laser procedure was acceptable to the patients as the procedure show a reduction of the treatment chair time more than conventional method (El Shenawy et al., 2015).

A one-step laser treatment is usually sufficient to eliminate the pigmented gingiva and does not require a periodontal dressing, easy handling, short treatment time, hemostasis, sterilization effects and excellent coagulation (small vessels and lymphatics) are its known advantages.

Laser surgery has some disadvantages like delayed healing and expensive, but until now laser ablation has been recognized as most effective, pleasant, and reliable technique for gingival melanin de pigmentation with acceptable esthetic result.

4.3 Conclusion

Both procedures did not result in post-operative complications (swelling, bleeding, and infection) for most of the subject's .In gingival depigmentation with diode laser the subjects complained of moderate pain while the site treated with diamond bur abrasion only mild pain was felt, although both sites show decrease in pain perception by the end of the first week. Despite the diode laser depigmentation was associated with delayed wound healing and sort of discomfort able for some subjects; most of the responders were very satisfied about the esthetic results and time preservation with diode laser therapy.

4.4 Recommendations

From the present study the following recommendations should be considered**:**

I. Increase the sample size of study populations.
II. Gingival depigmentation with different methods can be done with wide range of comparisons between them.
III. Extended time for follow- up and the degree of regimentation should be evaluated.
IV. Gingival depigmentation with different parameters of the semiconductor diode laser.

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Appendix (1): The Check List

Personal Data

Name: Sex:

Age: Marital status:

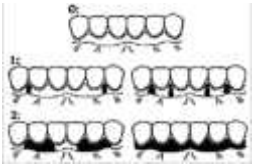
Occupation

Address: Tel No.

Ethnic group;

Clinical examination:

The degree of melanin pigmentation was determined by melanin pigmentation index based on the following scoring system:



Melanin pigmentation index

Score 0: No pigmentation

Score 1: Solitary unit(s) of pigmentation in papillary gingival without extension between neighboring solitary units

Score 2: Formation of continuous ribbon extending from neighboring solitary units

Clinical Assessment

Clinical Assessment of swelling, bleeding and infection (Gingival abrasion using diamond bur)

	Time for assessment		
Clinical assessment	3 hours	3 days	One week
Post operative swelling			
Post operative bleeding			
Post operative infection			

Clinical Assessment of swelling, bleeding and infection (Gingival de pigmentation by diode lasers)

	Time foe assessment		
Clinical assessment	3 hours	3 days	One week
Post operative swelling			
Post operative bleeding			
Post operative infection			

Pain perception (visual Analog Scale; VAS):

Visual Analog Scale; VAS

- 0 =no pain
- 0.1 to 3.0 cm (1 to 30 mm) = mild pain
- 3.1 to 6.0 cm (31 to 60 mm) = moderate pain
- 6.1to 10 cm (61 to 100 mm) = severe pain

Visual Analog Scale; VAS

	Time (period)		
Method	3 hours	3 days	One week
Rotary (diamond burs)			
Diode laser			

Patient satisfaction

1-Gingival de pigmentation using (diamond bur):

- Very satisfied
- Satisfied
- Neutral
- Moderate satisfied
- Unsatisfied

2- (Gingival de pigmentation by diode lasers):

- Very satisfied
- Satisfied
- Neutral
- Moderate satisfied
- Unsatisfied

WOUND HEALING

Wound healing was evaluated based on the following scores:
A. complete epithelization.
B. incomplete epithelization.
C. ulcer.
D. Tissue defect or necrosis.

	Wound healing evaluation			
Methods	3days	One week	Two weeks	Three weeks
Rotary (diamond burs)				
Diode laser				

Appendix (2)

A) Consent Form

I_____, have received information about this procedure (gingival melanin de pigmentation by using rotary abrasive technique (diamond bur) under local anesthesia). I have discussed my treatment with Dr._____ and have been given an opportunity to ask questions and have them fully answered. I understand the nature of the recommended treatment, alternate treatment options, and the risks of the recommended treatment.

I wish to proceed with the recommend treatment.

Signed: _____

Date: _____

Treating Dentist

Signed: _____

Date: _____

B) Consent Form

I_____, have received information about this procedure (gingival melanin depigmentation by using diode laser). I have discussed my treatment with Dr._____ and have been given an opportunity to ask questions and have them fully answered. I understand the nature of the recommended treatment, alternate treatment options, and the risks of the recommended treatment.

I wish to proceed with the recommend treatment.

Signed: _____

Date: _____

Treating Dentist

Signed: _____

Date: _____

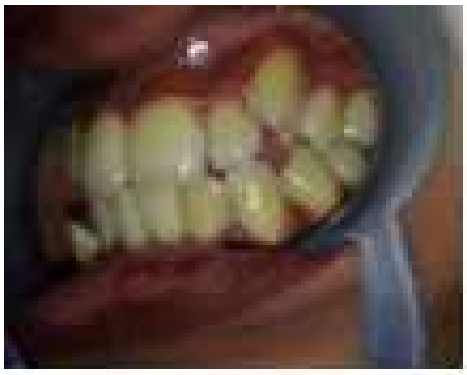
Appendix 3: Cases photographs

Case 1:

Pre-operative frontal view

Immediate post - operative view after diode laser depigmentation

Immediate post operative view (right)



Immediate post operative view (left)

Post operative view after three days

Post operative view after one week

Immediate Post - operative view after high speed diamond bur depigmentation

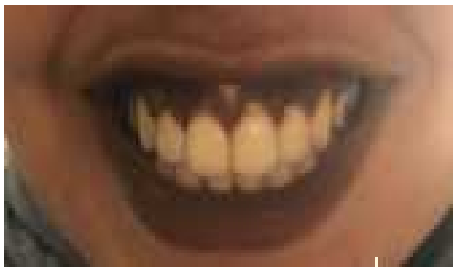
periodontal dressing

Post – operative view after two weeks

Post – operative view after two weeks

Post – operative view after two months

Case 2:



Pre-operative smile

Pre-operative frontal view

Immediate post operative view after diode laser depigmentation

After three days post operatively

Immediate post operative view after diamond bur depigmentation

Periodontal dressing

Post operative view (one month)

Post operative view (two months)

Post operative smile

Case 3:

Pre-operative frontal view

Immediate post - operative view after diode laser depigmentation

After three days post operatively

Post – operative view after one week

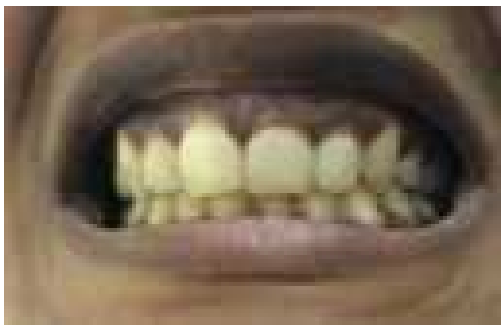
Post operative view after two weeks

Post Operative view after crown lengthing

Immediate post operative view after diamond bur depigmentation

periodontal dressing

Post operative view after one week



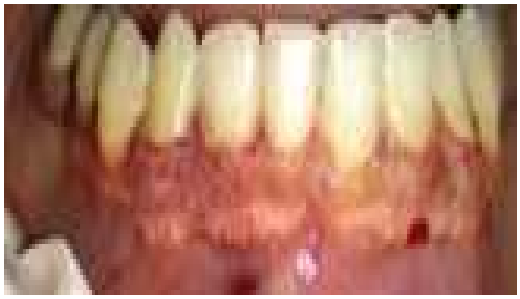
Before depigmentation

Post operative view (two months)

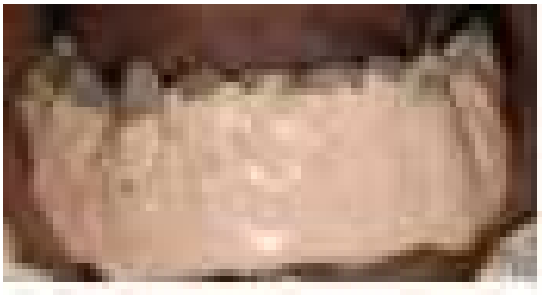
Case 4:

Pre operative frontal view

Gingival hyperpigmentation



Immediate post operative view after diamond bur depigmentation



Periodontal dressing

Post operative view after one week

Immediately after diode laser depigmentation

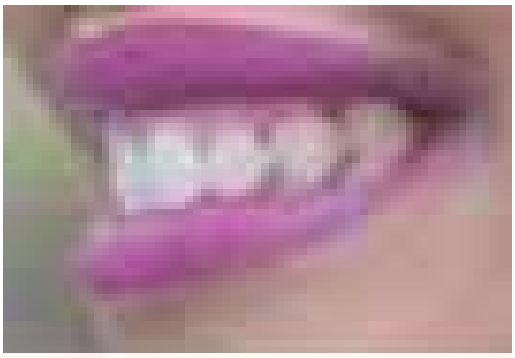
Post operative view after three days of depigmentation by diode laser

Post operative view after one week of gingival depigmentation by diode laser

Post operative view after two weeks

Post operative view after three months

Before gingival depigmentation



After three months

Case 5:

Pre-Operative Frontal View (gingival hyperpigmentation) .

Post – Operative view after three months

The upper gingival depigmentation is by diode laser (808 nm, 1, 5 watt)

The lower gingival depigmentation is by diamond bur abrasion

Case 6:

Pre- Operative Frontal View (gingival hyperpigmentation).

Post – Operative view after three months

The upper gingival depigmentation is by diode laser (808 nm, 1, 5 watt)

The lower gingival depigmentation is by diamond bur abrasion