Sudan University of Science and technology

Collage of graduate studies

Comparison between Diode Laser and abrasive bur techniques of gingival melanin depigmentation

المقارنة بين تقنيات الليزر الثنائي و تقنيات المثقب الكاشط لإزالة تصبغ اللثة بالملانين

Dissertation submitted in partial fulfillment for the requirement of the degree of higher diploma of laser application in medicine (dentistry)

By

Malaz Deya eldien Mohammed Mahmoud

Supervisor

Assoc.prof..Amna Algarrai

Assoc.prof.Sohad alwakeel

2022

List of content

DEDICATION

To my family,

Whose their love and encouragement make me able to get such success and honor.

ACKNOWLEDGMENTS

This research paper would not have been possible without the support and guiding of Allah.

We owe gratitude and gratefulness to Allah at first, and then to our family, friends and the supervisor Dr. Amna and Dr Suhad who were abundantly helpful and offered invaluable patience, assistance and guidance during the course of this study. We like to thank my patient that participate at this study. We like to thank also the staff of the institute of laser, at Sudan University of science and technology and for their continuous efforts to make this opportunity possible, and not forgetting colleagues who always been there.

Abstract

Background: Pigmentation of the gingiva plays a negative role in an otherwise acceptable “smile window”. In the present world, people are more concerned about their aesthetics.

Several techniques have been employed such as scalpel surgery, electrosurgery, cryosurgery, chemical agents, abrasion and LASER method for the removal of melanin hyperpigmentation.

Objectives :The present study is **aimed** at comparing the efficacy of Diode LASER and soft tissue Bur trimmer for gingival depigmentation.

Methods: Acase report study was conducted for one patient with gingival pigmentation. Dummet Oral Pigmentation Index (DOPI), Gingival Pigmentation Index (GPI) for pigmentation, bleeding factor, wound healing factor, gingival colour and visual analogue scale (VAS) score for pain were evaluated for Maxillary and mandibular arches at baseline, 7th day.

Results: The patient treated with diode laser experience less intra and post operative pain ,less local anathesia were used ,no bleeding and complete healing until 7^{th} day, As for bur trimmer mandibular attached gingiva more local anesthesia was used, more postoperative pain ,which disappear gradually until 7^{th} day, more intraoperative bleeding and incomplete wound healing at 7^{th} day.

Conclusion: It can be concluded that LASER and soft tissue trimmer both are comparable in achieving aesthetic satisfaction. Hence, the soft tissue trimmer could also be used for depigmentation as it is very cost effective, readily available and acceptable by the patients. Further long-term studies are needed to assess the effectiveness of the Soft tissue trimmer and diode LASER.

المستخلص

الخلفية: يلعب تصبغ اللثة دورا سلبيا في حياة الناس لأنه يعطي شكل إبتسامة غير مقبول. في الوقت الذي يتجه فيه العالم نحو الإهتمام أكثر بالشكل و النواحي الجمالية،.

تم استخدام العديد من التقنيات مثل جراحة المشرط والجراحة الكهربائية وجراحة التبريد والعوامل الكيميائية والتآكل وطريقة الليزر لإزالة فرط تصبغ الميلانين.

الأهداف: تهدف الدراسة الحالية إلى مقارنة فعالية الليزر الثنائي و تقنيات المثقب الكاشط للإزالة تصبغ اللثة.

الطرق: أجريت دراسة لحالة مريض واحد مصاب بتصبغ اللثة تم تقييم مؤشر تصبغ اللثة و لون اللثة و عامل النزيف و المقياس التناظري البصري للألم في لثة الفك السفلي و العلوي من اليوم الأول لليوم السابع

النتائج: عانى المريض من الم أقل أثناء وبعد الجراحة، وتم استخدام تخدير موضعي أقل، ولايوجد نزيف وشفاء كامل حتى اليوم السابع عند أستخدام الليزر الثنائي في لثة الفك العلوي على عكس الفك السفلي حيث شعر المريض بألم أكثر و كانت هنالك حوجة أكثر للتخدير الموضعي و نزيف و شفاء غير كامل عند اليوم السابع حين تم إستخدام المثقب الكاشط للإزالة تصبغ اللثة.

الخلاصة: يمكن استنتاج أن الليزر و المثقاب الكاشط لهم القدرة في تحقيق الرضا الجمالي. يمكن أيضا استخدام أداة المثقاب الكاشط لإزالة التصبغ لأنها فعالة جدا من حيث التكلفة ومتاحة بسهولة ومقبولة من قبل المرضى. هناك حاجة إلى مزيد من الدراسات طويلة الأمد.

LIST OF ABBREVIATIONS

GD	Gingival depigmentation
VAS	Visual analogue scale
DOPI	Dummet Oral Pigmentation index
GMH	Gingival Melanin Hyperpigmentation

CHAPTER ONE

1-1- Introduction:

The normal periodontium been divided into two main parts:

1- The gingiva, the main function of which is protecting the underlying tissues.

2- The attachment apparatus, composed of:

-The periodontal ligament,

- cementum.

-Alveolar bone.

When viewed clinically, the only portion of periodontium that is visible to the unaided eye is the oral aspect of the gingival epithelium.

The gingiva is that part of the oral mucosa overlying the alveolar processes of upper and lower jaws. It surrounds the neck of teeth at a level just coronal to the cemento-enamel junction.

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.(Heapt et al 2018,and Doshi Y, et al 2012)

One of the important factors in the ‘‘smile window’’ is the color of the gingiva. Several factors determine the color, including increase or decrease in blood vessels, thickness of the epithelium, extent of keratinization, and

endogenous and exogenous pigmentation. Physiologic pigmentation is symmetric, persistent, and does'not alter the normal architecture ,such as gingival stippling.(vishal S ,2012).

Physiologic pigmentation is mainly genetically determined; however, some other factors such as activity of endocrine glands, ultraviolet radiation, smoking, and medication can also cause gingival hyperpigmentation. It is a real esthetic concern for most of the individuals, especially in the anterior keratinized gingiva of the maxilla and mandible. (Elemek E, 2018)

Melanin is a brown pigment,which is the most common natural pigment contributing to endogenous pigmentation of the gingiva. It is a non–hemoglobin-derived pigment formed by cells called melonocytes that are dentritic cells of neuroectodermal origin in the basal and spinous layers.(Haebet et al,2018,and Elemek E, 2018).

Gingival hyperpigmentation occurs as triangular/ linear/diffuse patches of dark brown to black or light brown to yellow color. Pigmentation may be seen at any age irrespective of sex, although it varies among different races and population. and is usually limited to the keratinized mucosa(vishal s et al 2012). It can become an aesthetic issue for many patients, especially when it is located in the anterior labial gingiva, not uniform in appearance and is associated with a high smile line.(Elemek E 2018.)

Gingival depigmentation (GD) is defined as the periodontal treatment to remove melanin pigmentation on the gingiva.Five Different approaches are described in literature for GD, each presenting advantages and disadvantages. Burr abrasion, scraping with a scalpel, electro surgery, and

lasers are widely used and known to be effective GD approaches.(Bakhshi M et al,2015).

Laser use was once considered expensive and was rarely available in the dentistry clinics, but now **>20% of dentistry** clinics regularly use dental lasers. Research and innovation in the field of dentistry lasers has led to improvements in the ease with which the device is used [16]. Laser techniques, although still a developing technology, have already shown plenty of evidence for their effectiveness and efficiency, giving a strong reason to use it in dentistry. (Zarone F, 2017).

The mechanism of action is based on the thermal interaction as the laser produces heat and increases the kinetic energy of the targeted tissue along with effects, such as coagulation, vaporization, necrosis carbonization, and denaturation of tissues. (El Mobadder M et al,2018)

Therefore, the laser energy will cut, ablate, and reshape the gingiva easily. Lasers have an electromagnetic spectrum of wavelengths, and each wavelength has a specific interaction with the targeted tissue

As for the melanin pigmentation, the ability of the melanin-containing melanocytes to absorb the laser light also depends on the wavelength; diode lasers of wavelength 810–980nm are well absorbed by melanocytes. (Perveen A et al,2018.)

A relatively large number of studies on GD showed that the lasers can effectively remove the pigmentation. However, repigmentation, which is defined as the reappearance of melanin pigmentation in a period of time after GD treatment, is one of the major disadvantages of the procedure. In fact, a treatment can be considered a failure if the pigmentation reappears after a

short period of time. Nevertheless, in literature, the duration of pigmentation reappearance after treatment remains controversial.(Samir N et al,2019)

1-2- Justification:

Esthetics have become important in dentistry due to the increasing demand for a satisfactory smile and the major concern for beauty. For this reason, even when the GMH is not a medical problem, the demand for its removal is increasing, especially if the anterior gingiva of both maxilla and mandible is concerned for patients with gummy smile or excessive gingival display usually complain of black gum and request cosmetic therapy. Different approaches are described in literature for GD, each presenting advantages and disadvantages. Burr abrasion, scraping with a scalpel, electro surgery, and of the various types of lasers available for gingival depigmentation, diode lasers have several advantages, including their small size, affordable price, and diversity in terms of soft-tissue treatment applications, making them of great value to a dental practice**(Samir N et al,2019)**

1-3- Objectives:

General objective:

To compare the effectiveness of gingival depigmentation techniques using diode laser and abrasive burs.

Specific objectives:

1- To compare effectiveness of gingival depigmentation techniques using diode laser and abrasive burs.

2-To evaluate the need for anesthesia before procedure.

3-To evaluate the bleeding during surgical procedure.

4-To compare the pain after surgical procedure for both techniques laser and bur.

1-4-Previous studies :

Gingival depigmentation:

Gingival depigmentation is a periodontal plastic surgical procedure whereby the gingival hyperpigmentation is removed or reduced with the help of various techniques.

The first and foremost indication for depigmentation is the patient demand for improved aesthetics. In medical sciences, various depigmentation techniques have been employed with similar clinical results. In 2017, a similar study was carried out by Mahajan et al2 in which they compared depigmentation by the scalpel technique on one side and by the diode laser technique on the other side, and concluded that, on surgically treated sites, all cases showed repigmentation of the gingiva, but those treated with the laser technique did not show repigmentation of the gingiva even at the end of the 9-month observation time. The selection of a technique should be based on clinical experience and individual preferences.

The surgical methods of depigmentation include the scalpel surgical technique,3 cryosurgery,4 and electrosurgery.5 Recently, lasers of different varieties such as neodymium, aluminum-yttrium-garnet (Nd-YAG) lasers , diode lasers with different wavelengths, erbium-YAG lasers,and carbon dioxide (CO2) laser8 have also been commonly used with no side effects. (Elemek E,2018).

Literature today shows that the use of lasers for GD is a pleasant, comfortable, effective, and reliable treatment. The mechanism of action is based on the thermal interaction as the laser produces heat and increases the

kinetic energy of the targeted tissue along with effects, such as coagulation, vaporization, necrosis carbonization, and denaturation of tissues.Therefore, the laser energy will cut, ablate, and reshape the gingiva easily. Lasers have an electromagnetic spectrum of wavelengths, and each wavelength has a specific interaction with the targeted tissue. The Er:Cr:YSSG and Er:YAG lasers (each having a wavelength of 2790 and 2940nm, respectively), and the CO2 laser (having a wavelength of 10,600nm) produce invisible, infrared light, which is highly absorbed by water.7 Whereas, **semiconductor diode lasers (having of wavelength of 810–980nm)** produce invisible near-infrared light, which are weakly absorbed by water. As for the melanin pigmentation, the ability of the melanin-containing melanocytes to absorb the laser light also depends on the wavelength; diode lasers of wavelength 810–980nm are well absorbed by melanin pigmentation. (Samir Nammour et al,2019)

Also used for soft tissue coagulation and cutting. Diode laser irradiation also has bactericidal effect resulting in hemostasis. Having a high affinity to penetrate into hemoglobin and melanin pigments makes it the preferred laser for depigmentation of gingiva. Diode lasers can be used both in pulsed or continuous mode. Application of the laser in pulsed mode prevents overheating of surrounding tissues that may cause necrosis and jeopardize healing. Diode laser was used in continuous mode in other study conducted by Elemek E,2018 knowing the fact that it may penetrate deeper and affect connective tissue as well. That's why, the evaluations were also made at weeks 4 and 12. The use of lasers has several advantages such as no need to place a periodontal dressing, short healing period, no or very slight pain, no

hemorrhage. The only disadvantage may be the high cost of the lasers.(Elemek E,2018).

CHAPTER TWO:

Historical background and Litretue Review:

Litretue Review:

The oral mucosa :

consists of the following three zones:

1. The gingiva and the covering of the hard palate, termed the masticatory mucosa (The gingiva is the part of the oral mucosa that covers the alveolar processes of the jaws and surrounds the necks of the teeth.)

2. The dorsum of the tongue, covered by specialized mucosa.

3. The oral mucous membrane lining the remainder of the oral cavity Gingiva Clinical Features In an adult, normal gingiva covers the alveolar bone and tooth root to a level just coronal to the cementoenamel junction.

2-1- The gingiva :

The gingival epithelium consists of a continuous lining of stratified squamous epithelium. There are three different areas that can be defined from the morphologic and functional points of view:

1- The oral or outer epithelium.

2- The sulcular epithelium.

3- The junctional epithelium.

Is divided anatomically into :

1-Marginal.

2-Attached.

3- interdental areas.

Although each type of gingiva exhibits considerable variation in differentiation, histology, and thickness according to its functional demands, all types are specifically structured to function appropriately against mechanical and microbial damage.(CARRANZA'S CLINICAL PERIODONTOLOGY)

In other words, the specific structure of different types of gingiva reflects each one's effectiveness as a barrier to the penetration by microbes and noxious agents into the deeper tissue.

Marginal Gingiva:

The marginal or unattached gingiva is the terminal edge or border of the gingiva that surrounds the teeth in collarlike fashion. In about 50% of cases, it is demarcated from the adjacent attached gingiva by a shallow linear depression called the free gingival groove. The marginal gingiva is usually about 1 mm wide, and it forms the soft-tissue wall of the gingival sulcus. It may be separated from the tooth surface with a periodontal probe. The most apical point of the marginal gingival scallop is called the gingival zenith. Its apicocoronal and mesiodistal dimensions vary between 0.06 and 0.96 mm.

Gingival Sulcus:

The gingival sulcus is the shallow crevice or space around the tooth bounded by the surface of the tooth on one side and the epithelium lining the free margin of the gingiva on the other side. It is V-shaped, and it barely permits the entrance of a periodontal probe. The clinical determination of the depth of the gingival sulcus is an important diagnostic parameter. Under absolutely normal or ideal conditions, the depth of the gingival sulcus is 0 mm or close to 0 mm. These strict conditions of normalcy can be produced

experimentally only in germ-free animals or after intense and prolonged plaque control.

In clinically healthy human gingiva, a sulcus of some depth can be found. The depth of this sulcus, as determined in histologic sections, has been reported as 1.8 mm, with variations from 0 to 6 mm. other studies have reported 1.5 mm and 0.69 mm.The clinical evaluation used to determine the depth of the sulcus involves the introduction of a metallic instrument (i.e., the periodontal probe) and the estimation of the distance it penetrates (i.e., the probing depth). The histologic depth of a sulcus does not need to be exactly equal to the depth of penetration of the probe. The penetration of the probe depends on several factors, such as probe diameter, probing force, and level of inflammation Consequently. (CARRANZA'S CLINICAL PERIODONTOLOGY)

Interdental Gingiva:

The interdental gingiva occupies the gingival embrasure, which is the interproximal space beneath the area of tooth contact. The interdental gingiva can be pyramidal, or it can have a "col" shape. In the former, the tip of one papilla is located immediately beneath the contact point; the latter presents a valleylike depression that connects a facial and lingual papilla and that conforms to the shape of the interproximal contact.

The shape of the gingiva in a given interdental space depends on the presence or absence of a contact point between the adjacent teeth, the distance between the contact point and the osseous crest,and the presence or absence of some degree of recession. Depicts the variations in normal interdental gingiva. The facial and lingual surfaces are tapered toward the

interproximal contact area, whereas the mesial and distal surfaces are slightly concave. The lateral borders and tips of the interdental papillae are formed by the marginal gingiva of the adjoining teeth. The intervening portion consists of attached gingiva. If a diastema is present, the gingiva is firmly bound over the interdental bone to form a smooth, rounded surface without interdental papillae.

Microscopic Features:

Microscopic examination reveals that gingiva is composed of the overlying stratified squamous epithelium and the underlying central core of connective tissue. Although the epithelium is predominantly cellular in nature, the connective tissue is less cellular and composed primarily of collagen fibers and ground substance. These two tissues are considered separately.

Gingival Epithelium :

General Aspects of Gingival Epithelium Biology. Historically, the epithelial compartment was thought to provide only a physical barrier to infection and the underlying gingival attachment. However, we now believe that epithelial cells play an active

role in innate host defense by responding to bacteria in an interactive manner,which means that the epithelium participates actively in responding to infection, in signaling further host reactions, and in integrating innate and acquired immune responses.

The principal cell type of the gingival epithelium—as well as of other stratified squamous epithelia—is the **keratinocyte**. Other cells found in the epithelium are the **clear cells** or **nonkeratinocytes**, which include :

-The Langerhans cells.

-The Merkel cells.

- The melanocytes.

The main function of the gingival epithelium is to protect the deep structures while allowing for a selective interchange with the oral environment. This is achieved via the proliferation and differentiation of the keratinocytes. The proliferation of keratinocytes takes place by mitosis in **the basal layer** and less frequently in **the suprabasal layers**:

-Stratum spinosum

-Stratum granulosum

-Stratum cornum.

In which a small proportion of cells remain as a proliferative compartment while a larger number begin to migrate to the surface.

Differentiation involves the process of keratinization, which consists of progressions of biochemical and morphologic events that occur in the cell as they migrate from the basal layer . The main morphologic changes include the following:

(1) the progressive flattening of the cell with an increasing prevalence of tonofilaments.

(2) the couple of intercellular junctions with the production of keratohyalin granules.

(3) the disappearance of the nucleus.

A complete keratinization process leads to the production of an orthokeratinized superficial horny layer similar to that of the skin, with no nuclei in the stratum corneum and a well-defined stratum granulosum .

Only some areas of the outer gingival epithelium are orthokeratinized; the other gingival areas are covered by parakeratinized or nonkeratinized epithelium and considered to be at intermediate stages of keratinization. These areas can progress to maturity or dedifferentiate under different physiologic or pathologic conditions.

In **parakeratinized** epithelia, the stratum corneum retains pyknotic nuclei, and the keratohyalin granules are dispersed rather than giving rise to a stratum granulosum.

The nonkeratinized epithelium (although cytokeratins are the major component, as in all epithelia) has neither granulosum nor corneum strata, whereas superficial cells have viable nuclei. Non-keratinocyte cells are present in gingival epithelium as in other malpighian epithelia.

Melanocytes are dendritic cells located in the basal and spinous layers of the gingival epithelium. They synthesize melanin in organelles called premelanosomes or melanosomes.

Langerhans cells are dendritic cells located among keratinocytes at all suprabasal levels .They belong to the mononuclear phagocyte system (reticuloendothelial system) as modified monocytes derived from the bone marrow.

Merkel cells are located in the deeper layers of the epithelium; they harbor nerve endings, and they are connected to adjacent cells by desmosomes. They have been identified as tactile perceptors.

The epithelium is joined to the underlying connective tissue by a **basal lamina** 300 to 400 Å thick and lying approximately 400 Å beneath the epithelial basal layer.

The basal lamina consists of lamina lucida and lamina densa. Hemidesmosomes of the basal epithelial cells abut the lamina lucida, which is mainly composed of the glycoprotein laminin. The lamina densa is composed of type IV collagen.

The epithelial component of the gingiva shows regional morphologic variations that reflect tissue adaptation to the tooth and alveolar bone.These variations include the oral epithelium, the sulcular epithelium, and the junctional epithelium. Whereas the oral epithelium and the sulcular epithelium are largely protective in function, the junctional epithelium serves many more roles and is of considerable importance in the regulation of tissue health. It is now recognized that epithelial cells are not “passive bystanders” in the gingival tissues; rather, they are metabolically active and capable of reacting to external stimuli by synthesizing a number of cytokines, adhesion molecules, growth factors, and enzymes. The degree of gingival keratinization diminishes with age and the onset of menopause, but it is not necessarily related to the different phases of the menstrual cycle. Keratinization of the oral mucosa varies in different areas in the following order: palate (most keratinized), gingiva, ventral aspect of the tongue, and

cheek (least keratinized). (CARRANZA'S CLINICAL PERIODONTOLOGY)

2-2- Melanin:

Is a brown pigment, located in basal and suprabasal layers of gingival epithelium. It plays a main role in physiologic gingival pigmentation which is also determined by the thickness of epithelium, presence of blood vessels, and epithelium keratinization degree. Physiologic pigmentation is mainly genetically determined; however, some other factors such as activity of endocrine glands, ultraviolet radiation, smoking, and medication can also cause gingival hyperpigmentation. It is a real esthetic concern for most of the individuals, especially in the anterior keratinized gingiva of the maxilla and mandible.(Houshmand B,et al 2017)

Melanocytes are melanin-producing neural crest-derived cells located in the bottom layer (the stratum basale) of the skin's epidermis, the middle layer of the eye (the uvea),the inner ear,vaginal epithelium, meninges, bones, and heart.Melanin is a dark pigment primarily responsible for skin color. Once synthesized, melanin is contained in special organelles called melanosomes which can be transported to nearby keratinocytes to induce pigmentation. Thus darker skin tones have more melanosomes present than lighter skin tones. Functionally, melanin serves as protection against UV radiation.(Elemek E, 2018)

Melanocytes are also part of the immune system, and are considered to be immune cells. Although the full role of melanocytes in immune response is not fully understood, melanocytes share many characteristics with dendritic

cells: branched morphology; phagocytic capabilities; presentation of antigens to T-cells; and production and release of cytokines.

Although melanocytes are dendritic in form and share many characteristics with dendritic cells, they are derived from two different cell lineages. Dendritic cells are derived from hematopoietic stem cells in the bone marrow. Melanocytes on the other hand originate from neural crest cells. (Suragimath G et al ,2017)

As such, although morphologically and functionally similar, melanocytes and dendritic cells are not the same.

Through a process called melanogenesis, melanocytes produce melanin, which is a pigment found in the skin, eyes, hair, nasal cavity, and inner ear. This melanogenesis leads to a long-lasting pigmentation, which is in contrast to the pigmentation that originates from oxidation of already-existing melanin. (Abdullah BA et al ,2016)

There are both basal and activated levels of melanogenesis; in general, lighter-skinned people have low basal levels of melanogenesis. Exposure to UV-B radiation causes increased melanogenesis. The purpose of melanogenesis is to protect the hypodermis, the layer under the skin, from damage by UV radiation. The color of the melanin is black, allowing it to absorb a majority of the UV light and block it from passing through the epidermis.(Suragimath et al 2016).

The difference in skin color between lightly and darkly pigmented individuals is due not to the number (quantity) of melanocytes in their skin,

but to the melanocytes' level of activity (quantity and relative amounts of eumelanin and pheomelanin). This process is under hormonal control, including the MSH and ACTH peptides that are produced from the precursor proopiomelanocortin.

Vitiligo is a skin disease where people suffer from melanin lack in certain areas in the skin.

People with oculocutaneous albinism typically have a very low level of melanin production. Albinism is often but not always related to the TYR gene coding the tyrosinase enzyme. Tyrosinase is required for melanocytes to produce melanin from the amino acid tyrosine. Albinism may be caused by a number of other genes as well, like OCA2, SLC45A2,TYRP1, and HPS1 to name some. In all, already 17 types of oculocutaneous albinism have been recognized.Each gene is related to different protein having a role in pigment production.

People with Chédiak–Higashi syndrome have a buildup of melanin granules due to abnormal function of microtubules. (El Mobadder M,et al,2018)

2-3- Laser :

The acronym LASER, constructed from Light Amplification by Stimulated Emission of Radiation(SILFVAST 2004).

Components Lasers :

1-Active Medium :

May be: Solid crystals such as ruby or Nd:YAG, liquid such as dyes, gases like CO2 or Helium/Neon, semiconductors such as GaAs.

Active mediums Contain atoms whose electrons may be excited to a metastable energy level by an energy source(SILFVAST 2004).

2-Excitation Mechanism:

Excitation mechanisms pump energy into the active medium by one or more of three basic methods;

-Optical.

-electrical.

- chemical .(SILFVAST 2004).

3-Mirrors :

-High Reflectance Mirror:

A mirror which reflects essentially 100% of the laser light.

-Partially Reflective Mirror:

A mirror which reflects less than 100% of the laser light and transmits the remainder(SILFVAST 2004).

Lasing Action :

Energy is applied to a medium in order to raising electrons to an unstable energy level.

These atoms spontaneously decay to a relatively long-lived, lower energy, metastable state. A population inversion is achieved when the majority of atoms have reached this metastable state. Lasing action occurs when an electron spontaneously returns to its ground state and produces a photon. If

the energy from this photon is of the precise wavelength, it will stimulate the production of another photon of the same wavelength and resulting in a cascading effect.

The highly reflective mirror and partially reflective mirror continue the reaction by directing photons back through the medium along the long axis of the laser.

The partially reflective mirror allows the transmission of a small amount of coherent radiation that we observe as the "beam". Laser radiation will continue as long as energy is applied to the lasing medium(SILFVAST 2004).

Spontaneous emission and stimulated emission:

Stimulated emission: the excited atoms interact with a pre-existing photon that passes by. If the incoming photon has the right energy, it induces the electron to decay and gives off a new photon. Ex. Laser.

Spontaneous emission: Photons emitted in all directions and on a random time scale. The emitted photons are incoherent like neon light, light bulb(SILFVAST 2004).

Laser Properties:

The light emitted from a laser is:

1-Monochromatic, that is, it is of one color/wavelength.

2-Directional, that is, laser light is emitted as a relatively narrow beam in a specific direction.

3-Coherent, which means that the wavelengths of the laser light are in phase in space and time.

4-High intensity: which can be defined as the number of photons emitted per unit surface area per unit solid angle. Even lasers with low intensity, compared with other lasers, are intense more than the sun light. This property is due to huge number of coherent photons emitted with very small angle (little divergence)(SILFVAST 2004).

Types of laser:

Lasers may be classified according to the type of active medium, excitation mechanism, and region of emitted wavelength or mode of operation. According to the active medium, lasers are classified to: solid, gas, liquid and semiconductor lasers. According to the spectral region of the emitted laser, the classification is: UV, visible and I.R. lasers. Based on the mode of operation lasers are classified to : continuous wave (CW), chopped, pulsed and ultra short pulsed lasers (SILFVAST 2004)

According to the active medium lasers are classified as:

I. Solid State Lasers :

lasers contains solid crystalline or glass material as an active medium, this lasers sometimes called doped lasers because this lasers are available in combination of hosts and dopant material.

The commonly used host materials are:

Yttrium aluminum garnet (YAG) is the crystal host for Nd: YAG lasers.

Glass is also used as a host for neodymium lasers.

Crystal like Sapphire, tungsten oxide.

The dopant material

These materials dispersed in the host to act as active centers, examples for doped materials are: the ions of chromium, neodymium and erbium.

The basic arrangement and principle of all solid state laser systems is same

These systems use a laser rod placed closed to a optical pump source to focus light in to the rod .These laser get excessively heated and to control the heat, the system is provided with a coolant

Advantage of Solid Laser :

1-Can produce high power pulse lasers

2-The energy in these laser can be trapped for a longer time as the lifetime of the atoms at the metastable state is longer.

3-Also these lasers (four levels) can be used for CW power operation as the active density of ion is large

The types of lasers which fall in this category are:

Ruby laser .Nd-YAG ,Nd-Glass, Alexandrite and titanium sapphire laser(SILFVAST 2004)

II. Gas lasers:

In gas laser the active material used is a gas at low pressure, which can be excited either by electrical discharge or by optical pumping, may be operated in either CW or pulsed modes.

The gas lasers are classified into three groups:

1-Atomic or neutral atom lasers: He –Ne, He-Cd, copper vapour and gold vapour

2-Ionic lasers: Argon ion , Krypton ion laser

3-Molecular gas lasers : CO2 , N2 , Excimer lasers (SILFVAST 2004)

III. Liquid Lasers :

The active medium used is organic dye dissolved in a liquid solvent (alcohol), can be pumped optically by a laser or by a flash lamp and used elliptical reflectors

The dye lasers are tunable up to large wavelengths. Desired wave length at the output can be extracted by using wavelength selector switches like diffraction grating in the cavity. It is easy to change the active medium for desired application. The cooling is simple as the flowing liquid takes heat along with it. The dye lasers become popular because it is cheap and simple. Have very short pulses

Disadvantage

The excitation by other laser makes the system little complicated

Dye used toxic material,

They have short life time and needs early replacement

The application

Due to the fluorescence characteristic, dye laser is useful in diagnostic spectroscopy, kill tumor, destroy kidney stones and for photodynamic therapy(SILFVAST 2004).

IV. Semiconductor (Diode) Lasers

These lasers are the most common lasers .The semiconductor laser have long life and high efficiency and require low power for operation. It is so tiny.

A semiconductor is a material which has electrical Properties in between those of conductor and insulators

The active medium of a semiconductor laser is the junction between two types of semiconductor materials; Gallium arsenide (GaAs) is an example of a material used in the manufacture of a semiconductor laser.

Current flow across the junction is the excitation mechanism. In semiconductors, there are two energy levels (bands), conduction band and valence band

The population inversion or lasing is occur when the population of the electrons in the conduction band increases over the population of the electron in the valence band to create this situation a doped semi conductors are used

A doped semiconductors is one in which trivalent (P- type) or pentavalent (n- type) impurity is added for extra energy levels to the semi conductors(SILFVAST 2004)

Delivery systems

Free beam, articulated arm, and optical fibers (SILFVAST 2004)

Laser medical application:

From the historic point of view, lasers were first applied in ophthalmology. This was obvious, since the eye and its interior belong to the easiest accessible organs because of their high transparency.

And it was only a few years earlier that Meyer-Schwickerath (1956) had successfully investigated the coagulative effects of xenon flash lamps on retinal tissue. In 1961, just one year after the invention of the laser, first experimental studies were published by Zaret et al. (1961). Shortly afterwards, patients with retinal detachment were already being treated as reported by Campbell et al. (1963) and Zweng et al. (1964). At the same time, investigations were first carried out in dentistry by Goldman et al. (1964) and Stern and Sognnaes (1964).

In the beginning, laser treatment was limited to the application of ruby lasers. Later on, other types of lasers followed. And, accordingly, clinical research extended within the disciplines of ophthalmology and dentistry. Starting in the late 1960s, lasers were introduced to other medical disciplines, as well. And today, a large variety of laser procedures is performed all over the world. Most of them belong to the family of minimally invasive surgery (MIS), a special term reserved for low-trauma and bloodless surgical procedures. It's basically these two characteristics that have promoted lasers to being a universal scalpel and tool for treatment.

Many patients, and also surgeons believed in lasers as if they were some kind of magical instruments. This attitude evoked misleading statements and unjustified hopes. Careful judgment of new developments is always

appropriate, and not every reported laser-induced cure can be taken for granted until it is reconfirmed by independent studies. Laser-induced effects are manifold as will be shown in this book. Most of them can be scientifically explained. However, the same effect which might be good for a certain treatment can be disastrous for another. For instance, heating of cancerous tissue by means of laser radiation might lead to desired tumor necrosis. On the other hand, using the same laser parameters for retinal coagulation can burn the retina, resulting in irreversible blindness. Thermal effects, in particular, tend to be irreversible if temperatures > 60◦C are achieved.(laser tissue interaction springer 2019)

Laser systems are classified as:

1- **continuous wave** (CW) lasers

2- **pulsed** lasers.

Whereas most gas lasers and to some extent also solid-state lasers belong to the first group, the family of pulsed lasers mainly includes solid-state lasers, excimer lasers, and some diode lasers. **list of medical laser types and two of their characteristic parameters is given below : wavelength and pulse duration**. The list is arranged with respect to the latter one, since the duration of exposure primarily characterizes the type of interaction with biological tissue, The wavelength is a second important laser parameter. It determines how deep laser radiation penetrates into a tissue, that is how effectively it is absorbed and scattered. Frequently, a third parameter – the applied energy density – is also considered as being significant. However, its value only serves as a necessary condition for the occurrence of a certain effect and then determines its extent. Actually, all medically relevant effects

take place at energy densities between 1J/cm2 and 1000J/cm2. This is a rather narrow range compared to the 15 orders of magnitude of potential pulse durations.

A fourth parameter – the applied intensity – is given as the ratio of energy density and pulse duration. Each laser type listed in list below is used for particular clinical applications.

List of some medical laser systems

Laser type Wavelength Typical pulse duration

Argon ion 488/514nm CW

Krypton ion 531/568/647nm CW

He-Ne 633nm CW

CO2 9.6/10.6μm CW or pulsed

Dye laser 450–900nm CW or pulsed

Diode laser 405–3330nm CW or pulsed

Ruby 694nm 1–250μs

Nd:YLF 1053nm 100ns–250μs

Nd:YAG 1064nm 100ns–250μs

Ho:YAG 2120nm 100ns–250μs

Er:YSGG 2780nm 100ns–250μs

Er:YAG 2940nm 100ns–250μs

Alexandrite 720–800nm 50ns–100μs

XeCl 308nm 20–300ns XeF 351nm 10–20ns

KrF 248nm 10–20ns ArF 193nm 10–20ns

Nd:YLF 1053nm 30–100ps

Nd:YAG 1064nm 30–100ps

Free electron laser 800–6000nm 2–10ps

Ti:Sapphire 700–1000nm 10fs–100ps

Chapter three

Materials and Methods :

3-1- Study Design :

Case report, split-mouth.

3-2- Study Population:

Patient complaining of gingival pigmentation.

3-3- Study Area :

Dr.Modather Implantology Dental clinic.

3-4- Sample size :

1 patient , maxillary and mandibular attached gingiva.

The maxillary attached gingiva was treated with laser.

The mandibular attached gingiva was treated with bur.

3-4-1- Inclusion Criteria :

1- Patients with healthy periodontium. .-

2-suffering from uniformly dense bands of bilateral gingival hyperpigmentation.

3- having a primary concern for aesthetics in the anterior region.

3-4-2- Exclusion Criteria :

1-Any systemic disease that would contraindicate the use of Laser therapy (eg, malignant neoplasias), metabolic diseases (eg, diabetes).

2- Chronic pain.

3-Neurological or psychiatric disorders.

4- Use of medications (antibiotics, corticosteroids, bisphosphonates, analgesics, antiinflammatory agents, or contraceptives) taken up to 1 month before the selection exam.

5-pregnant or lactating women .

6- patient with smoking habits.

3-5- Ethical consideration :

Approval letter from the Ethical Committee of the University of Sudan was obtained prior to the condition of the study.

The aim and the methods of the study was explained verbally to the participants.

Participant approval and written consent was obtained.

3-6- Data analysis:

3-6-1- Study Protocol:

The research included the following clinical evaluation parameters:

1. Dummet Oral Pigmentation Index (DOPI) by Dummet and Gupta (1964)[4]: The index is used

to score gingival pigmentation and intensity of gingival hyperpigmentation. Scoring criteria

are as follows:

0- No clinical pigmentation (pink gingiva)

1- Mild clinical pigmentation (mild brown color)

2- Moderate clinical pigmentation (medium brown or mixed pink and brown color)

3- Heavy clinical pigmentation (deep brown or bluish black color)

2. Gingival Pigmentation Index by Kumar S (2012): The index is used to score

gingival pigmentation and extent of gingival hyperpigmentation. Scoring criteria are

as follows:

0- Absence of pigmentation

1- Spots of brown to black colour or pigments

2- Brown to black patch but not diffuse pigmentation

3- Diffuse brown to black pigmentation, marginal, and attached

The purpose of using two indices in the present study was to obtain more precise results as the DOPI is based on the color intensity and the gingival pigmentation is based on the location and extent.

Visual analogue scale (VAS) for pain:

The Visual analogue scale(VAS) was used to measure the intensity of pain experienced during and after treatment. The Visual analogue scale (VAS) consists of a horizontal line 100 mm long, anchored at the left end by the descriptor “no pain” and at the right end by ‘‘unbearable pain”. The patient placed a mark to coincide with the level of pain.

The Visual analogue scale (VAS) score was recorded during intraoperative treatment phase, and all the patients were recalled after 1st day and at 7th day for pain assessment.

3-6-2- Case report:

After clinical examination patient score of gingival pigmenation in Dummet Oral Pigmentation Index (DOPI) was 3 , and other Index by Kumar S (2012) was also 3, that indicated that the patient had sever gingival pigmentation.

Depigmentation with diode LASER:-

For the maxillary arch Topical anesthetic spray was applied to the surgical field. Local infiltration with anesthetic solution Lignox® (2% lignocaine with 1:200,000 adrenaline) was given only when discomfort was experienced by the patient.

Depigmentation procedure was applied by 810 nm and 980 wavelengths diode laser (Cheese® Wuhan, China). The fiber-optic laser tip at 1.5 W power(0.75w +0.75w) in continuous mode was kept in contact with the pigmented area. Depigmentation was performed in a horizontal direction, using the laser tip in contact mode on the pigmented part of the gingiva and parallel to the root surfaces not to cause overheating, and the area depigmented was wiped with gauze soaked in saline . After the procedure, no periodontal dressing was applied and no antimicrobials were prescribed. Patients were instructed to avoid smoking and hot, acidic, and spicy food that can jeopardize the healing process and cause patient discomfort.

Depidmentation with bur:

For the mandibular arch Local infiltration with anesthetic solution Lignox® (2% lignocaine with 1:200,000 adrenaline) was given .

Depigmentation with precision soft tissue trimmer or bur ,trimmer was used in the high-speed rpm without water coolant spray to excise and contour soft

gingival tissue. The heat produced by the bur due to friction results in an immediate tissue coagulation and minimal bleeding, therefore, the use of coolant (water) was avoided.

After removing the entire pigmented epithelium with precision soft tissue trimmer, the exposed surface was irrigated with saline. Care was taken to see that all remnants of the pigmented layer were removed. The surgical area was then covered with a Coe- PakTM (GC America).

Following depigmentation, patients were recalled at weeks 1 day and 1 week during postoperative period for clinical evaluation.

Patients mentioned a mild sensitivity only at the day of the surgery. No postoperative pain, hemorrhage, or scarring was observed , and the healing was uneventful. At week 1, gingiva showed a rapid but immature epithelialization, gingiva appeared pale pink which was satisfactory for patient and operator.

Chapter four:

Results and discussion :

4-1 Results:

Dummet Oral Pigmentation **index** (DOPI) values for LASER and bur were 3 at baseline, after 7th day was 0 for both laser and bur.

Intra-operatively moderate **bleeding** was seen in bur of the mandibular attached gingiva while no bleeding observed with LASER. At 7th day mandibular and maxillary gingiva showed no bleeding with bur and laser.

Complete **wound healing** was seen at 7th day on the laser treated sites when compared to bur treated sites.

The **VAS (pain) score** for the LASER arch the intraoperative pain was scored at around 4 and 2 , that reduced to 0 at 1st day until the 7^{th} day. In bur arch VSA score was 4 and 6 intraoperative that reduced to 4and 3 at 1 st day , with gradual decrease in pain and sensitivity until 7^{th} day,no pain was experienced at 7th day for both laser and bur arches.

Significant improvement in gingival **color** was seen at 7th day of both gingival arches.

4-2 Discussion:

We know that physiologic gingival melanin pigmentation is not a medical

problem, but patients may complain of unaesthetic “black gums”. The patient’s smile window is directly hampered. Ginwalla et al (1966) described the broad black zone of pigmentation on the gingiva as “unsightly” and suggested its removal.

gingival pigmentation showed that “pink gum” is the ideal one. In this study The DOPI scores were significantly reduced from baseline for both arches of laser and bur trimming side , Similar results have been shown by the studies of Rao PVN et al (2014) and Kaur H et al (2010). This was in accordance with the studies conducted by Abdullah BA et al (2014)[16] and Kumar S et al (2013).

In the present study, **bleeding** during surgery was assessed between both

techniques. LASER treated areas showed relatively less or no bleeding than soft tissue trimming bur treated area. This may be because, initiation of tip provides a hot tip effect, which helps in concentrating energy at the tip. This helps in removing the superficial layer of epithelium without bleeding or trauma to mucosa. Furthermore, the blood vessels surrounding tissue up to a diameter of 0.5 mm were found to be sealed by LASER, thus providing haemostasis which aids the operator with a relatively clean and

dry field. Similar results have been shown by the study conducted by Shenawy H M et al (2015).18 and Rohini Negi,et al 2018 where The bur treated tissue resulted in an immediate tissue coagulation and minimal

bleeding caused by the rotational energy of the bur precision soft tissue trimmer. But slight to moderate bleeding was recorded.

Wound healing was assessed after 7 days, in mandibular arch the bur

showed incomplete wound healing and in case of LASER, in maxillary arch showed complete healing whereas similar results found by Rohini Negi,et al 2018.

The **pain perception** was less in the LASER maxillary arch as protein coagulum forms on the wound surface. Irradiation might act as a biological wound dressing sealing the ends of sensory nerve endings. The present study results were in accordance with the study conducted by Lagdive et al (2009)[6] where they compared scalpel and diode LASER group of patients experiencing significantly less pain compared to scalpel group. In the present study, VAS for LASER and bur was highly significant intraoperatively and at day 1 until 7^{th} day. The results showed that most of the LASER treated site showed slight or no pain, whereas, bur treated patients reported moderate to sever pain decreased gradually until 7^{th} day.,this results consistent with other study conducted by Rohini Negi,et al 2018.

Re-pigmentation is described as spontaneous and has been attributed to the activity and migration of melanocytic cells from surrounding areas. In the present study the follow up period was so short to determine recurrence but in other study done by Kaur H et al (2010).

The laser treated site showed recurrence in 16 patients out of 20 patients each, as in accordance with the study Re-pigmentation, here does not mean that the whole of the segment or arch was pigmented, but even a small dot or streak in relation to a single tooth was considered as re-pigmentation in that segment

4-3- Conclusion :

It can be concluded that, both arches showed almost complete depigmentation and similar aesthetic results. Ablation and abrasion techniques were good enough to achieve aesthetic satisfaction and fair wound healing without infection or pain. The use of soft tissue trimmer is easy, inexpensive as compared to diode LASER. Hence it is more acceptable to the patients and operator. Further long-term studies are needed to assess the effectiveness of the Soft tissue trimmer and diode LASER.

4-4- Recommendation and limitation:

Increasing sample size for the study.

Increasing study duration and follow up .

Increasing awareness of patient of various laser types and their effects.

References:

Abdullah BA, Al-shmaah,2014,The use of ErCr:YSGG versus diode LASER in gingival melanin depigmentation. Intnational Journal of Enhanced Research in Science Technology and Engineering;3:12-21.

Bakhshi M, Rahmani S, Rahmani 2015,A. Lasers in esthetic treatment of gingival melanin hyperpigmentation: a review article. Lasers Med Sci;30:2195–2203.

CARRANZA'S CLINICAL PERIODONTOLOGY, 12TH EDITION ISBN: 978-0-323-18824-1

Elemek E. 2018 Gingival melanin depigmentation by 810 nm diode laser. Eur J Dent;12:149-52. DOI: 10.4103/ejd.ejd_373_17

El Mobadder M, Farhat F, El Mobadder W, Nammour S. 2018,Photobiomodulation therapy in the treatment of oral mucositis, dysgeusia and oral dryness as side-effects of head and neck radiotherapy in a cancer patient: a case report. Dent J (Basel);6:64.

El Shenawy HM, Nasry SA, Zaky AA, Quriba MA 2015. Treatment of gingival by diode laser for esthetical purposes. Maced J Med Sci;3:447-54.

Doshi Y, Khandge N, Byakod G, Patil P 2012. Management of gingival pigmentation with diode laser: Is it a predictive tool? Int J Laser Dent;2:29-32.

Harpreet Singh Grover, Himanshu Dadlani, Amit Bhardwaj, Anil Yadav, Sanjay La 2014, Evaluation of patient response and recurrence of pigmentation following gingival depigmentation using laser and scalpel

technique: A clinical study, Journal of Indian Society of Periodontology - Vol 18, Issue 5.

Houshmand B, Janbakhsh N, Khalilian F, Talebi Ardakani MR 2017. Efficacy of conventional laser irradiation versus a new method for gingival depigmentation (Sieve method): A clinical trial. J Lasers Med Sci;8:88-

Kaur H, Jain S, Sharma L S 2010. Duration of reappearance of gingival melanin pigmentation after surgical removal – A clinical study. J Ind Soc Periodontol

;14:101-5.

Kumar S, Bhat GS, Bhat MK 2013. Comparative evaluation of gingival depigmentation using tetraflouroethane cryosurgery and gingival abrasion technique: Two years follow up. J Clin Diagn Res;7:389-94.

Nagati R, Ragul M, Qahtani Nabeeh A, Ravi KS, Tikare S, Pasupuleti MK 2017. Clinical effectiveness of gingival depigmentation using conventional surgical scrapping and diode LASER technique: A quasi experimental study. Global Journal of Health Science;9:296-03.

Pavlic V, Brkic Z, Marin S, Cicmil S, Gojkov-Vukelic M, Aoki A, et al 2017. Gingival melanin depigmentation by er: YAG laser: A literature review. J Cosmet Laser Ther;6:1-6.

Perveen A, Molardi C, Fornaini C 2018. Applications of laser welding in dentistry: a state-of-the-art review. Micromachines;9:209.

Rao PVN, Penmetsa GS, Dwarakanath C.D 2014. Gingival depigmentation by cryosurgery and LASER application- A comparative clinical study. Br J Med Med Res;5:1404-1412.

Shenawy HM, Nasry SA, Zaky AA, Quriba Mohamed A 2015. Treatment of gingival hyperpigmentation by diode LASER for esthetical purpose. Open Access Maced J Med Sci;15:447-54.

Shah C, Dave R, Shah M, Dave D 2014. Evaluation of scalpel versus diode laser for gingival depigmentation: A case report. Int J Adv Health Sci;1:24-7.

Samir Nammour Marwan El Mobadder, ,1 Me´lanie Namour, Amaury Namour, Eric Rompen, Elie Maalouf, Aldo Brugnera Junior, Ana Paula Brugnera, Paolo Vescovi, and Toni Zeinoun 2019, A Randomized Comparative Clinical Study to Evaluate the Longevity of Esthetic Results of Gingival Melanin Depigmentation Treatment Using Different Laser Wavelengths (Diode,CO2,andEr:YAG), Photobiomodulation, Photomedicine, and Laser Surgery Volume XX, Number XX,.

Suragimath G, Lohana MH, Varma S 2016. A split mouth randomized clinical comparative study to evaluate the efficacy of gingival depigmentation procedure using conventional scalpel technique or diode laser. J Lasers Med Sci;7:227-32

SILFVAST, W. T. (2004). Specific laser system. U S A, University of Cambridge.

Springer Nature Switzerland AG 2019 M. H. Niemz, Laser-Tissue Interactions, https://doi.org/10.1007/978-3-030-11917-1_1

Vishal Singh,* Subraya Bhat Giliyar,* Santhosh Kumar,* and Mahalinga Bhat 2012* Comparative Evaluation of Gingival Depigmentation by Diode Laser and Cryosurgery Using Tetrafluoroethane: 18-Month Follow-Up, Clinical Advances in Periodontics, Vol. 2, No. 3.

Zarone F, Leone R, Ferrari M, Sorrentino R 2017. Treatment concept for a patient with a high smile line and gingival pigmentation: a case report. Int J Periodontics Restorative Dent;37:e142–e148.