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Institute of Laser for Postgraduate Studies

Treatment of physiological gingival hyperpigmentation using 940 nm diode laser (a comparative in vivo study)

A Thesis Submitted to the Institute of Laser for Postgraduate Studies, University of Baghdad in Partial Fulfillment of the Requirements for the Degree of Master of Science in Laser / Dentistry

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بسم الله الرحمن الرحيم

وما أوتيتم من العلم إلا قليلا (٨٥)

صدق الله العظيم

سورة الأسراء: الأية ٨٥

Dedication

To my parents

Who stood by my side and supported me at every moment, they are the reason of what I've become. Thank you from the deepest of my heart

To my family

For my wife who supported me and helped me to pass a lot of difficulties, also for my son Abbas and my daughter Farah who were the reasons for my dedication.

To my colleagues

Thank you all for your help and kindness and I wish you all the success and luck in your life.

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ABSTRACT

Background: Gingival hyperpigmentation is one of the most common problems that requires an aesthetic treatment. It is usually caused due to excessive deposition of melanin at the basal layer of epithelium by melanocyte cells. Many depigmentation techniques have been developed which include: scalpel surgery, abrasion by dental bur, cryosurgery, electro surgery, graft surgery, chemical agents and lasers. **The aim of the study** was to compare between 940 nm diode laser and conventional bur method in management of gingival hyperpigmentation. **Materials and methods**: eighteen patients were selected with age 12-37 years old. The upper gingiva was the site that treated in this study. The upper right half of gingiva was treated by diode laser while the upper left half was treated using conventional bur method. All patients were re-evaluated after 3 days ,7 days, 1 month and after 6 months postoperatively. Pain, discomfort, healing, functions and recurrence of pigmentation were evaluated each visit, bleeding and duration of surgery were evaluated intraoperatively. Diode laser (λ=940 nm) with a fiberoptic delivery system was used in the study. Laser parameters were including 1.5 W in continuous mode with initiated tip (400 μm) that placed in contact with tissue. **The results** include a significant difference were observed in pain, discomfort, functions, bleeding, duration of the procedure, while no significant differences were observed for healing and re-pigmentation among groups. **Conclusion of the study** was that diode laser is considered as an effective in pain, discomfort, functions, bleeding and duration of the surgery compared to conventional method, while for healing and re-pigmentation both laser and conventional method has the same results after depigmentation.

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List of Abbreviations

Abbreviations	Terms
CO2	Carbon dioxide
Nd:YAG	Neodymium doped Yttrium –Aluminum Garnet
Er:Cr:YSGG	Erbium doped chromium:Yattrium, Scandium, Gallium and Garnet
Er:YAG	Erbium-doped: Yttrium, Aluminum, and Garnet
KTP	Potassium titanyl phosphate
mm	millimeter
μm	micrometer
nm	nanometer
cm^2	Centimeter square (unit of area)
DGF	Dentogingival fibers
CF	Circular fibers
TF	Trensseptal fibers
UV	Ultraviolet
DNA	Deoxyribonucleic acid
DOPA	Dihydroxyphenylalanine
DHI	Dihydroxyindole
DHICA	Dihydroxyindole carboxylic acid
ACTH	Adrenocorticotropic hormones
HIV	Human immunodeficiency virus
DOPI	Dummet oral pigmentation index
LASER	Light amplification by stimulated emission of radiation
CW	Continuous wave
μs	Microsecond

ms	Millisecond
W	Watt (unit of power)
J	Joule (unit of energy)
Hz	Hertz
m	meter
ATP	Adenosine triphosphate
Hb	Hemoglobin
TNF	Tumor necrosis factor
S	Second
^{o}C	Degree Celsius
eV	Electron volt
NOHD	Nominal ocular hazard distance
NHZ	Nominal hazard zone
ml	Milliliter
InGaAs	Indium-Gallium-arsenide
mg	Milligram
VAS	visual analog scale

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Chapter One
Introduction and Basic Concepts

CHAPTER ONE

Introduction and Basic Concepts

1.1 Introduction

Aesthetic becomes one of the most important needs for self-confidence during daily individual's life like laughing, smiling and making communications with other individuals. One of the most important structure of the oral cavity that sometimes require a cosmetic modification is gingiva. Gingiva is usually appear as a coral pink in color, however the color of gingiva is affected by a various of factors such as vascular supply, thickness and degree of keratinization of epithelium and presence of pigments within the epithelium [1].

A lot of pigments are usually associated with gingival pigmentation these are melanin, carotene, reduced hemoglobin, melanoid and oxyhemoglobin, however melanin is the most common pigment associated with gingival pigmentation [2]. Melanin is produced by melanocyte cells which are located in the basal layer of epidermis; thus, excessive deposition of melanin can lead to gingival hyperpigmentation [3]. Gingival hyperpigmentation appears as a dark or brown discolored area of diffuse or solitary units with defined margins especially in the labial aspect of gingiva and can be seen more clearly in Caucasian and dark-skinned people [4]. The number of melanocytes in those people and fair-skinned ones is the same, but the difference here is the activity of melanocytes [5]. Genetics, endocrine disturbances, inflammation, smoking, heavy metals and some medications are potential causes of gingival hyperpigmentation [6]. Gingival hyperpigmentation does not consider as a disease but the patient tries to manage this condition for aesthetic reasons especially those with high lip line (gummy smile) [7].

A lot of depigmentation techniques were developed in order to resolve this problem such as depigmentation using surgical scalpel [8], abrasion by dental bur [9], graft surgery [10], cryosurgery [7], electro surgery [11] and by lasers like diode laser [12], Nd:YAG laser [5], Er: Cr: YSGG [3], Er: YAG laser [13], and CO_2 laser [14].

1.2 Clinical features of gingiva

Gingiva is a part of periodontium that are firmly bound to the underlying alveolar bone and give support to tooth structure. Gingiva is coral pink in color with texture having stippling and translucence appearance like orange peel appearance with scalloped contour [15]. Gingiva is continuous with oral mucosa and the junction between them is called mucogingival junction. Anatomically the gingiva is divided into marginal gingiva, attached gingiva and interdental gingiva [16]. Anatomical landmarks of gingiva are shown in figure (1-1).

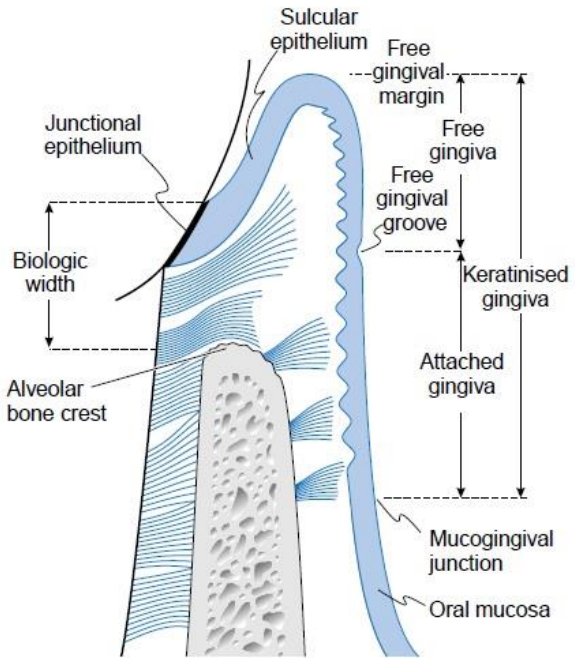

Figure 1-1: Diagrammatic representation of the epithelial and connective tissue attachments of the gingiva [17].

I. Marginal gingiva

It surrounds the tooth like a collar and represent the terminal edge of gingiva, usually can be separated from tooth surface using periodontal probe. The width of marginal gingiva is about 1mm and forms the soft tissue wall of gingival sulcus. In about 50% of cases free gingival groove is present which is a shallow depression that demarcate the marginal gingiva from adjacent attached gingiva [18].

II. Attached gingiva

It is tightly bound to the periosteum of alveolar bone with firm and resilient texture and it is continuous with marginal gingiva [16]. On the facial aspect of maxilla, mandible and the lingual aspect of mandible the attached gingiva is demarcated from movable alveolar mucosa by mucogingival junction while on the palatal surface the attached gingiva blend with palatal mucosa that has a similar firmness and resilient as the attached gingiva [19].

III. Interdental gingiva

It is a pyramidal in shape and occupies the interproximal area. Interdental gingiva is consisting of a facial and a lingual papilla and the col which is the depression between the two papillae that conforms the interproximal contact area [20]. Many factors can affect the shape of interdental gingiva such as absence of the contact area, variation in contact point and osseous crest distance and presence of gingival recession [21].

IV. Gingival sulcus

It is a shallow space around the tooth that bound by the tooth surface on one side and the free gingival margin on the other side. It is

act by preventing bacteria and fluid entrance to underlying tissue and act as a barrier against subgingival plaque. The depth of the gingival sulcus in a healthy gingiva has been reported as 1.8 mm [22], while other studies reported the depth equal to 1.5 mm [23] and 0.69 [24].

1.3 Histological features of gingiva

1.3.1 Gingival epithelium

Gingival epithelium is composed of a continuous lining of stratified squamous epithelium with three different areas these are: oral epithelium, sulcular epithelium and junctional epithelium. Keratinocytes are the major cells of gingival epithelium, other cells types include Langerhans cells, Markel cells and melanocytes cells [25]. Melanocytes cells are located in the basal layer of gingival epithelium, they are dendritic and synthesize melanin in organelles called melanosomes [26]. Their number in the skin and mucosa is the same but their activity in the skin is less than that of the mucosa [27]. Langerhans cells are located at the supra-basal layer of gingival epithelium, they are dendritic and considered as macrophages producing antigens. These cells are usually found in oral and sulcular epithelium but not in junctional epithelium [28]. Markel cells are present in the deeper layers and by harboring the nerve endings, they are considered as a tactile preceptor [29].

1.3.2 The areas of gingival epithelium:

(A) Oral epithelium

It is 0.2 to 0.3 mm thick and cover the outer surface of marginal and attached gingiva. Oral epithelium is para-keratinized and It is composed of four layers (figure 1-2) which include: stratum basale, stratum spinosum, stratum granulosum and stratum corneum [30].

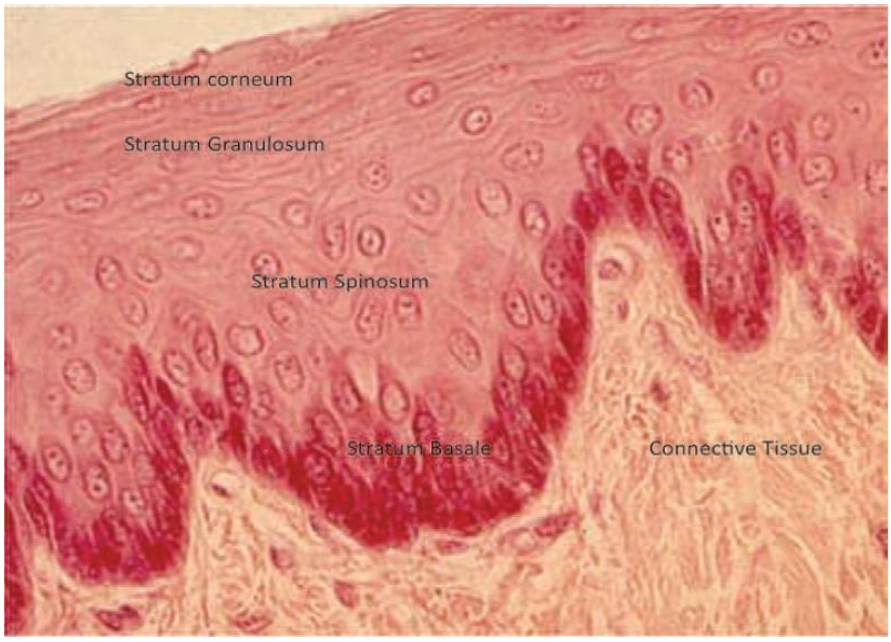

Figure 1-2: Cellular layers of epithelium [31].

(B) Sulcular epithelium

The gingival sulcus is lined with this type of epithelium which is nonkeratinized stratified squamous epithelium. It is thin and extends from the coronal margin of junctional epithelium to the crest of marginal gingiva [32]. Sulcular epithelium acts as a semipermeable membrane which allow the passage of bacterial products into the gingiva or tissue fluid from gingiva to the sulcus [33].

(C) Junctional epithelium

It is non-keratinized stratified squamous epithelium that forms a collar like band around the tooth. Coronally the Junctional epithelium is about 10-29 cells wide then it is tapered apically toward cementoenamel junction with 1-2 cells width and length ranging from 0.25 to 1.35 mm [34]. Junctional epithelium acts as a barrier that prevent bacteria from colonizing in subgingival surface of the tooth

while allowing the passages of gingival fluid and inflammatory cells to the gingival margin [36].

1.3.3 Restoration of gingival epithelium

It is found that there is a balance between the formation of new cells and mitotic rate of gingival epithelium during animal experiments. This balance is varying among different areas, It begins with buccal mucosa in descending order towards hard palate, sulcular epithelium, junctional epithelium, outer surface of gingival margin and the attached gingiva [37]. Due to the continuous restoration of gingival epithelium, It takes about 5 to 6 days for the palate, tongue and the cheek to renewal and 10 to 12 days for the gingiva while the junctional epithelium require 1 to 6 days [38]. This continuous renewal of the gingival epithelium is because there is a continuous shedding of cells. The shedding is acts as a defense mechanism against bacteria that adhere to epithelial cells [36].

1.3.4 Gingival connective tissue

It is called lamina propria and It is comprising of two layers:(a) the papillary layer which has a papillary projection and positioned beneath the epithelium and (b) the reticular layer which is adjoining with periosteum of alveolar bone [39]. Collagen fibers are the major component of gingival connective tissue which is about (60%) by volume, other component include: nerves, vessels and matrix about (35%) and fibroblasts which is about (5%) by volume [35]. Figure (1-3) shows the different types of gingival fibers with their orientations.

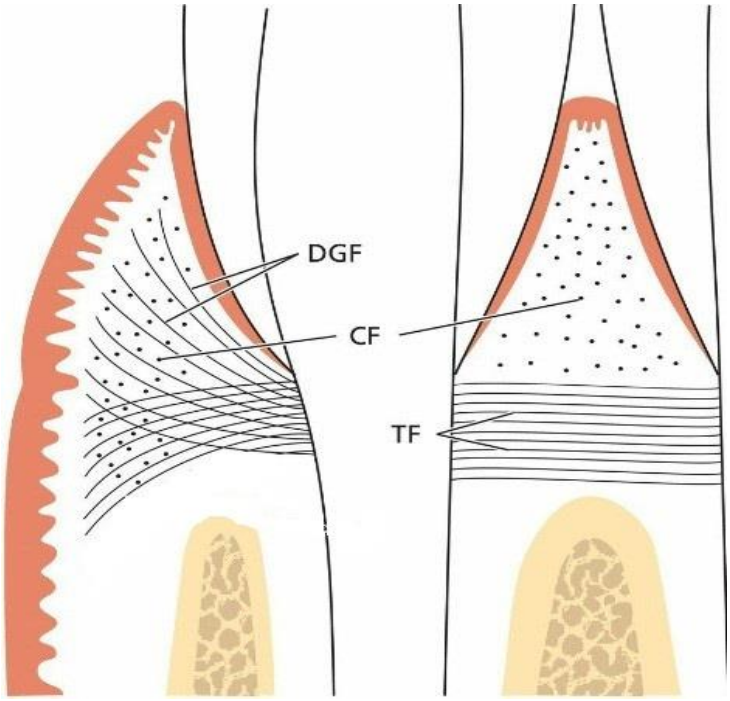

Figure 1-3: Illustrates of gingival fiber and their orientation including (dentogingival, circular and trans-septal fiber bundles [40].

1.3.5 Cellular features of gingival connective tissue

Fibroblasts are the major cellular elements of the gingival connective tissue that found between fiber bundles. It is responsible for production of different types of fibers; thus, fibroblast play an important role in repair and maintenance of gingival connective tissue [41]. Other cells include mast cells, macrophages, adipose cells, eosinophils, plasma cells, lymphocytes and neutrophils [42].

1.3.6 Blood supply of gingiva

A) Supra-periosteal arterioles that runs along the facial and lingual surface of alveolar bone [43]. B) Vessels of periodontal ligament. C) Anastomosis between the arterioles from interdental septa, periodontal ligament vessels, the capillaries in the gingival crevicular area and alveolar bone crest vessels [44].

1.3.7 Lymphatic system of gingiva

The incisors region of mandibular gingiva is drains into submental lymph node. Maxillary palatal gingiva is drains into deep cervical lymph node. The premolars and molars region of mandibular gingiva and maxillary buccal gingiva are drains into submandibular lymph node. Maxillary and mandibular third molars region are drains into jugulodigastric lymph node [40].

1.3.8 Nerve supply of gingiva

For maxillary gingiva, the facial aspect of incisors, canines and premolars are innervated by superior labial branches of infraorbital nerve while the buccal aspect of gingiva is innervated by posterior superior alveolar nerve branches. The incisor region of palatal gingiva is innervated by sphenopalatine nerve while the rest of palate is innervated by greater palatine nerve [40]. For mandibular gingiva, the facial aspect of incisors and canines are innervated by mental nerve while the buccal aspect of molars is innervated by buccal nerve. An overlap between the mental and buccal nerve innervation area usually supply the gingiva at premolar area. The lingual aspect of gingiva is innervated by sublingual nerve which is a branch of lingual nerve [40].

1.3.9 Healing of the gingiva

The healing sequence of gingiva after an injury or surgery include 3 phases which are [45]:

A) Inflammatory phase.

B) New tissue formation phase.

C) Remodeling phase

The inflammatory phase includes the activation of immune system to prevent infection and to remove any debris, also hemostasis to prevent tissue fluid's loss is achieved by platelet which plays an important role in cell aggregations and proliferations of keratinocytes due to its growth factors that releases [46].

New tissue formation phase (which occur between the 2nd and 10th day after injury) includes:

1)aggregations and proliferations of epithelial cell including keratinocytes and basal epithelial cells to provides new cells to close the wound.

2)Differentiation of myofibroblasts which plays an important role during healing by secreting matrix components and remodeling of the tissues that are newly formed [47].

3) Formations of new capillaries and blood vessels (angiogenesis) [48].

The final phase of healing sequence is the tissue remodeling phase which includes apoptosis of macrophages, myofibroblasts and endothelial cells leaving the new tissues which are composed mostly of collagen. One of the important process that occur during this phase is the exchange of collagen type III that present in the wound area by fibrous collagen type I. This phase is usually starts between the 2nd 3rd week after injury [45].

1.4 Gingival hyperpigmentation

Gingival hyperpigmentation (figure 1-4) could be either physiological or pathological. Physiological pigmentation is caused due to increase the activity of melanocyte cells which lead to increase the production of melanin [49]. Physiological pigmentation appears as light brown to black pigments that seen clearly in dark-skinned people

and It is affected by smoking, medication and hormones [50]. The most common location of physiological pigmentation is the attached gingiva but some time can be seen in other locations of the oral cavity like dorsum of the tongue [51].

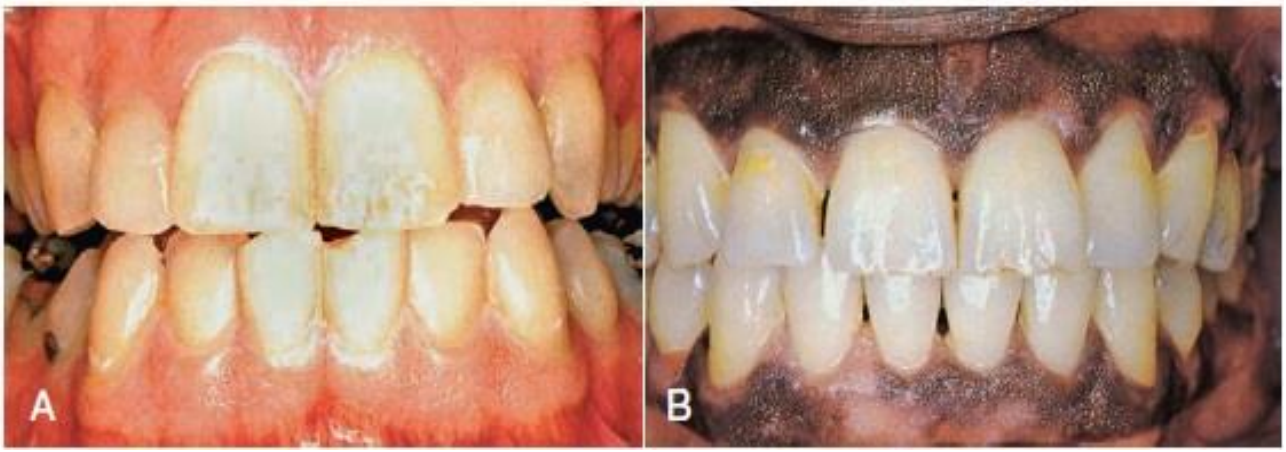

Figure 1-4: **A,** Clinically normal gingiva in a young adult. **B,** Heavily pigmented (melanotic) gingiva in a middle-aged adult [52].

Pathological pigmentations are caused due to certain inflammatory diseases like oral lichen planus, pemphigus or pemphigoid [50]. Pathological pigmentation has the same clinical appearance of physiological pigmentation Except that these pigments can be seen near vesicular lesions in the oral cavity [53]. Generally, melanin, melanoid, oxyhemoglobin, reduced hemoglobin and carotene are the primary pigments that responsible for gingival hyperpigmentation [54]. Figure (1-5) shows the deposition of melanin pigments at the basal cell layer.

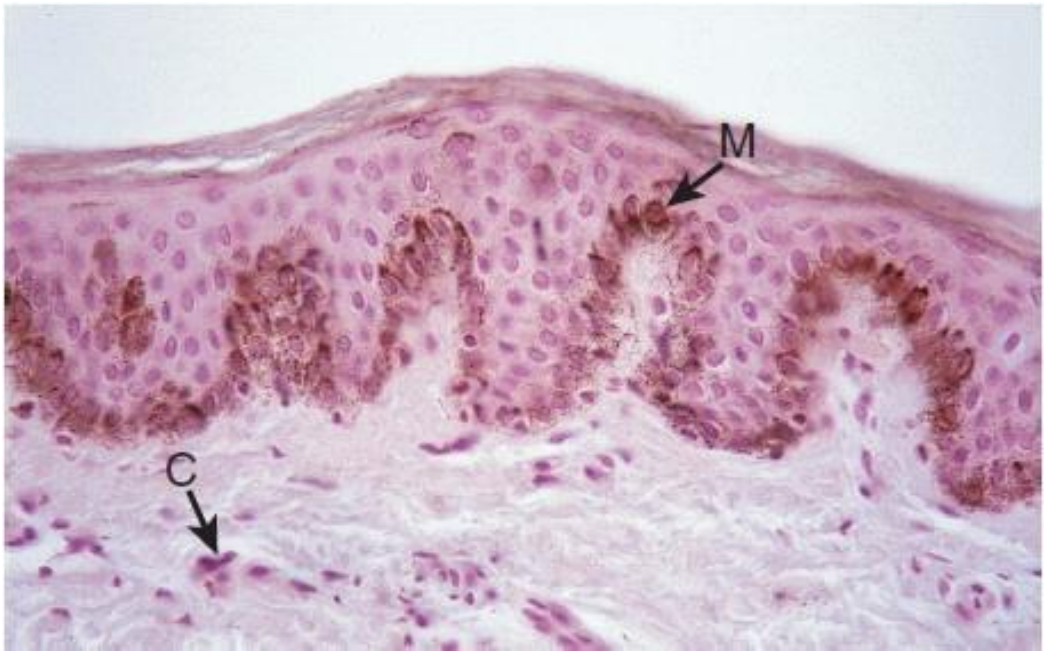

Figure 1-5: Pigmented gingiva showing melanocytes*(M)* in the basal epithelial layer and melanophores *(C)* in the connective tissue [52].

I. Melanin

This pigment is produced by melanocyte cells which is located in epithelium's basal layer. Melanin is a non-hemoglobin derived brown pigment which is considered the most common endogenous pigment [55]. One of the most important function of melanin pigments is that It absorbs UV radiation and by that It protect the DNA from ionization and damaging effect. The absorbed UV radiation then is converted into heat by process called ultrafast internal conversion [56]. Other functions of melanin are that it is responsible for skin, hair, mucosa and iris coloration as well as a part of brain.

II. Melanoid

Melanoid granules are usually scattered through stratum lucidum and stratum corneum of skin and It reflects a clear yellow shade to skin [54].

III. Oxyhemoglobin and reduced hemoglobin

Capillaries and venous plexuses also gives a shining color through the skin. These two pigments are resulting from hemosiderin deposits [54].

IV. Carotene

A deep yellow color is given to the skin by this pigment which is found in the lipid of stratum corneum and stratum lucidum. This pigment is found more likely in women than in men [55].

1.4.1 Melanin synthesis

Melanin synthesis begins when phenylalanine hydroxylase converts phenylalanine into tyrosine, this takes place in the liver. Next, an enzyme called tyrosinase converts tyrosine into DOPA quinine by oxidation. After that this pathway is divided to produce either eumelanin or pheomelanin [57]. For eumelanin the DOPA quinine is then undergoes further cyclization to 5,6-dihydroxyindole (DHI) or 5,6-dihydroxyindole-2-carboxylic acid (DHICA). After that tyrosinase oxidize (DHI) into indole-5,6-quinone which lead to formation of black or brown pigment called eumelanin. For pheomelanin the DOPA quinine undergoes cysteinylation into cysteinylDOPA by the help of glutathione. After that the cysteinylDOPA polymerize into various derivatives of benzothiazines which lead to formation of yellow or red pigment called pheomelanin [58]. Figure (1-5) shows the complete melanogenesis process.

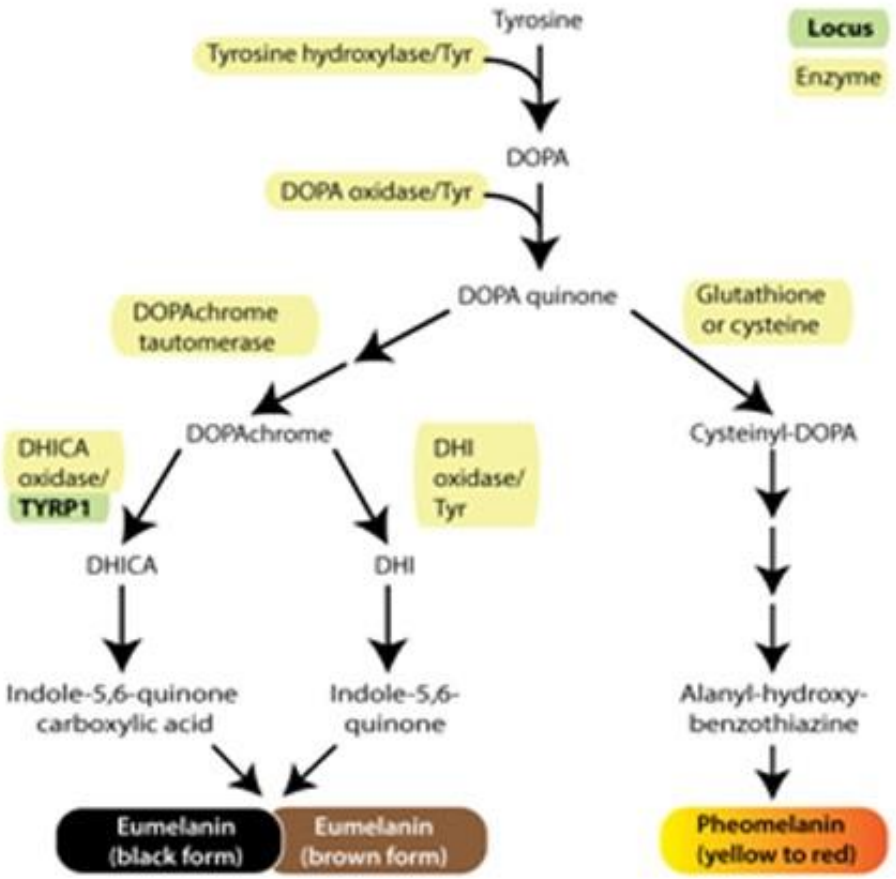

Figure 1-6: Melanin synthesis pathways (melanogenesis) [59].

These reactions are takes place in a special membrane-bound organelle called melanosomes [60]. After that melanin is transferred from melanocytes cytoplasm into keratinocytes basal cytoplasm via dendritic process.

1.4.2 Etiology of gingival hyperpigmentation

Gingival hyperpigmentation can be classified into either diffuse bilateral or focal pigmentations (Figure 1-7).

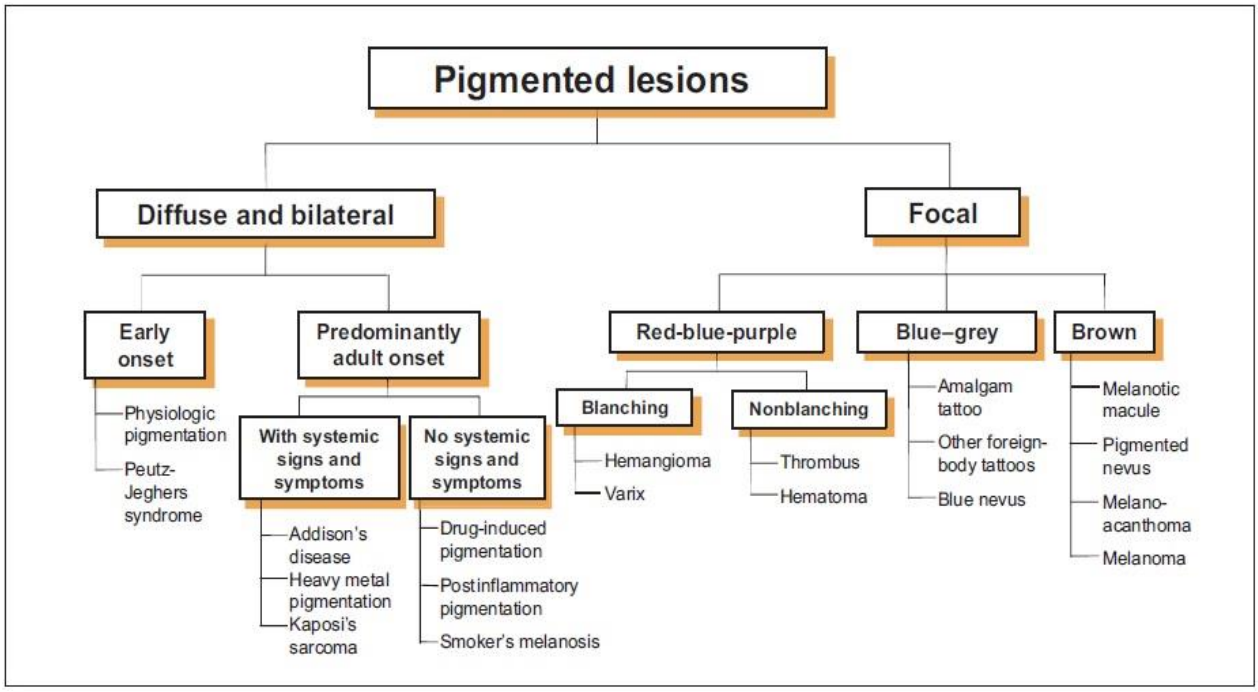

Figure:1-7: An algorithm for evaluation of pigmented lesions of the oral cavity [53]

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A) Diffuse bilateral pigmentations which includes:

1) Peutz-Jeghers Syndrome

It is a genetic disorder characterized by mucocutanous pigmentations and intestinal hamartomas with increased risks of small intestine, colon, stomach, pancreas, breast and genital tract cancer. The pigmented spots are small and multiple with 1 to 10 mm in diameter and can be found on the lower lip and buccal mucosa, but It is rare on the upper lip, gingiva, tongue and palate [61].

2) Addison's Disease:

Autoimmune diseases, malignancy and infection can sometimes lead to progressive adrenal cortex destruction [62] which result in

insufficiency of adrenocortical hormones in blood. This insufficiency will stimulate the production of adrenocorticotropic hormones (ACTH). The ACTH is produced by interior pituitary gland and with increases Its production induces melanocyte-stimulating hormone which result in diffuse brown patches on the gingiva, palate, tongue and buccal mucosa [63].

3) Heavy metals pigmentations:

Heavy metals such as (lead, bismuth, mercury, silver, arsenic and gold) can cause oral pigmentations when their levels in the blood are increased. This type of pigmentation can occur either in adults due to occupational exposure to the vapors of heavy metal and also due to drugs containing heavy metals or It can occur in children due to consumption of lead-containing water or due to drugs-containing heavy metals[63].Exposure to Bismuth, arsenic, and mercury produces black line that follows the gingival margin while exposure to lead produces bluish red to deep blue pigmentation of marginal gingiva, other metals like silver can cause violet pigmentation of gingival margin sometimes accompanied with bluish-grey pigmentation through oral mucosa[52].

4) Kaposi’s Sarcoma:

Kaposi's sarcoma can be seen predominantly in HIV-infected individuals as a multifocal vascular malignancy that can be seen more likely in the palate, gingiva and the tongue. The lesion at the early stage appear as a brown to purple flat or slightly elevated lesion while in advance stage It appears as plaques or nodules with dark red to purple discoloration that display ulceration, bleeding and necrosis [64].

5) Drug-Induced Pigmentation

A lot of medications can cause oral pigmentation depending on the type of the drug which can cause depositions of drugs or It's metabolites, stimulate the synthesis of pigments and deposition of iron after dermal vessels damage [65]. A group of drugs (figure 1-8) which is chloroquine and other quinine derivatives that used in treatment of malaria, cardiac arrhythmia and rheumatoid arthritis produces oral pigmentations that described as blue–grey or blue–black discoloration which can be seen most likely in the palate [66]. These drugs can cause a direct stimulus to melanocytes which lead to increase the production of melanin [67]. Also, minocycline which is a synthetic tetracycline that used in treatment of acne vulgaris, can cause pigmentation of alveolar bone and soft tissue include hard palate, gingiva, mucous membranes, and the Tongue which is usually seen as brown discoloration [68].

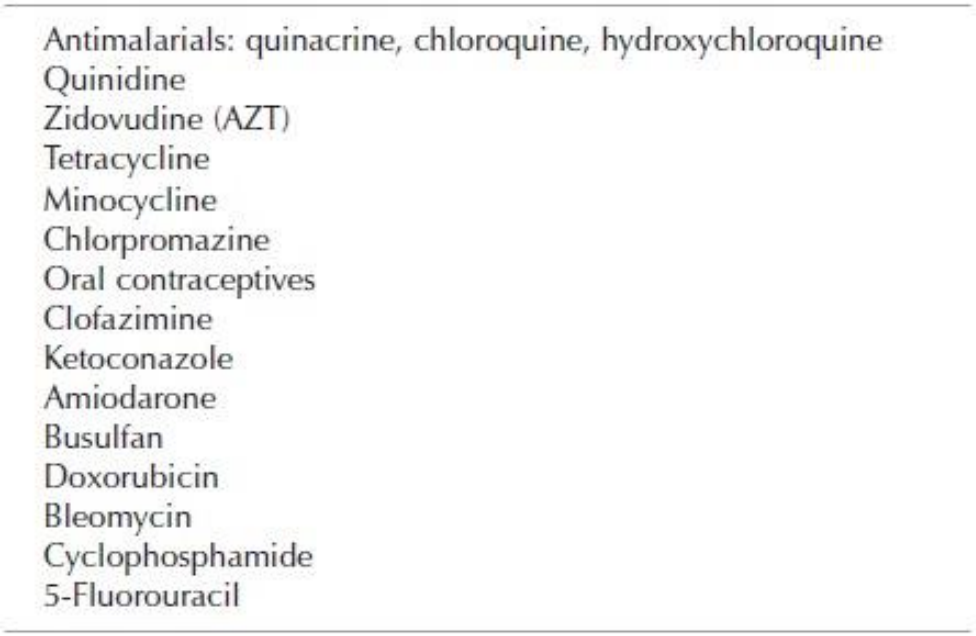

Figure 1-8: Drugs associated with oral mucosal Pigmentation [68].

6) Post-inflammatory pigmentations

Lichen planus, a long standing inflammatory disease can cause multiple brown–black pigmentations next to the reticular or erosive lesions which can be seen more likely in dark-skinned individuals [69].

7) Smoker's melanosis

About 22% of smokers reflects smoker's melanosis which is usually occur as a biological defense against noxious agents that is found in tobacco smoke. The higher the duration of smoking the more intensity of pigmentations, also the synergistic effect between sex hormones and smoking makes the females more affected than males. The pigmentations are appear as brown to black in color that can be seen more clearly on the labial aspect of gingiva and less frequently on buccal gingiva [70].

B) Focal pigmentations which includes:

1) Hemangioma and Vascular Malformation:

These are developmental abnormalities occur during infancy, for hemangioma, it will regress with age while vascular malformation persists. Hemangioma is a benign proliferation of the endothelial cells that line vascular channels while vascular malformation is a structural abnormalities of blood vessels without endothelial proliferation. Both lesions have the same clinical features of flat or slightly elevated lesion with red to bluish purple color and the most common site in oral cavity is the tongue. The color of the lesion depends on the type of vessels (capillaries, veins or arteries) and lesion's depth in tissues [71].

2) Hematoma and Other Hemorrhagic Lesions:

The lesion is usually appear as a flat or elevated pigmented lesion caused by extravasation of blood inside the soft tissues as can be seen in Hematomas, petechiae, purpurae and ecchymoses. The lesion is usually red, purple, blue or bluish black depending on how many long the blood has been in extravesicular space. The lesion is usually occur due to trauma or due to systemic condition and this variation in color is due to degradation of hemoglobin to bilirubin and biliverdin [71].

3) Amalgam Tattoo and other Foreign-Body Pigmentation:

This lesion can be seen mostly on the gingiva and alveolar mucosa but it also can be seen on buccal mucosa and floor of the mouth and it is representing the most common cause of oral pigmentation. The lesion occurs due to traumatic implantation of amalgam filling particles inside the soft tissue during dental practice and it is usually appears as bluish or black isolated areas on oral mucosa [72]. Also, accidental trauma with graphite pencils especially in children can lead to grey or black pigmented areas due to implantation of graphite within the soft tissue [63].

4) Melanotic Macules:

The lesion can be seen most widely on the gingiva, buccal mucosa and the palate as a light or dark brown pigmentation smaller than 1 cm in diameter with well demarcated border. The lesion is usually benign and occur in females more than in male and it is usually caused due to increase the activity of melanocytes which lead to increases melanin production [73].

5) Pigmented Nevi

Pigmented nevi are uncommon pigmentation of the oral cavity and they are usually appear as a brown or blue macules. The histological features of the lesion include nevus cells accumulation in the basal layer of epithelium and the connective tissue; thus, they are classified into compound or blue nevi, junctional nevi and intramucosal or intradermal nevi. The most common type of nevi is the intramucosal nevi that are usually found on buccal mucosa as a light brown macule while the second most common type are the compound or blue nevi which is found on the palate as a blue macule [74].

6) Oral Melanoacanthoma

It is a benign proliferation of dendritic process of melanocytes that are scattered throughout the thickness of the epithelium surface which is hyperkeratotic in nature. This lesion is usually occur on the buccal mucosa as a flat or slightly elevated pigmented area ranging from dark brown to black in color with the tendency to enlarge which gives the possibility of malignancy during clinical differential diagnosis, but in fact it has no malignant potential [75].

7) Oral Melanoma:

It is a malignant proliferation of melanocytes, it is asymptomatic and usually appears as black macules that are slowly growing or rapidly enlarging mass accompanied with bone destruction, ulceration, pain and bleeding. Oral melanoma occurs mostly in males rather than females. The most common oral sites that are affected include: the palate, upper gingiva and alveolar mucosa [76].

1.4.3 Gingival pigmentation indices:

A lot of indices have been used to evaluate the distribution, etiology and severity of gingival pigmentation. These indices include:

1) Oral pigmentation index(DOPI) which proposed by Dummet CO, Gupta OP in (1964). It is the most commonly used index due to its simplicity [77]. The score of this index include:

• No clinical pigmentation (pink-colored gingiva)

• Mild clinical pigmentation (mild light brown color)

• Moderate clinical pigmentation (medium brown or mixed pink and brown color).

• Heavy clinical pigmentation (deep brown or bluish black color).

2)Melanin index which is proposed by Hedin CA in (1977) with scores that include [78]:

• No pigmentation

• One or two solitary unit(s) of pigmentation in papillary gingiva without the formation of a continuous ribbon between solitary units

• More than three units of pigmentation in papillary gingiva without the formation of a continuous ribbon

• One or more short continuous ribbons of pigmentation

• One continuous ribbon including the entire area between canines

3)Melanin pigmentation index which proposed by Hanioka T in (2005) with scores include [79]:

• 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

4) Gingival pigmentation index which proposed by Kumar S (2012) with scores include [80]:

• Score 0: Absence of pigmentation

• Score 1: Spots of brown to black color or pigments.

• Score 2: Brown to black patches but not diffuse pigmentation

• Score 3: Diffuse brown to black pigmentation, marginal, and attached

5)The most recent index used to evaluate gingival pigmentation was proposed by(Peeran et al (2014)) with scores include [81] table (1-1) :

Table 1-1: Gingival pigmentation index by Peeran et al (2014)

CLASS	CRITERIA OF CLASSIFICATION
I	Coral pink/salmon pink colored gingiva
II	Localized/Isolated spots/areas of gingival melaninpigmentation which does not involve all the three parts of gingiva, that is, attached, free, and papillary gingiva Mild to moderate pigmentation Severe/intense pigmentation
III	Localized/Isolated unit/s of melanin pigmentationwhich involve all the three parts of gingiva, that is, attached, free, and papillary gingiva Mild to moderate pigmentation Severe/intense pigmentation
IV	Generalized diffuse pigmentation which involveall the three parts of gingiva that is, attached, free, and papillary gingiva. Mild to moderate pigmentation Severe/intense pigmentation
V	Tobacco associated pigmentation like smoker's melanosis and chewing tobacco
VI	Gingival pigmentation due to exogenous pigments eg:-Amalgam tattoos, Cultural gingival tattooing, Drinks, Food colors, Habitual betelnut/khat chewing, Lead-Burtonian line,Mercury, Silver, Arsenic, Bismuth, Graphite, Other foreign bodies, Topical medications,Idiopathic.
VII	Gingival pigmentation due to endogenous pigments like Bilirubin, Blood breakdown products, Ecchymosis, Petechiae, Hemochromatosis, Hemosiderin.
VIII	Drug-induced gingival pigmentation like ACTH, Antimalarial drugs, Chemotherapeutic agentbusulfanand doxorubicin, Minocycline, Oral contraceptives, Phenothiazines.
IX	Gingival pigmentation associated with systemic diseases and syndromes like Addison's disease, Albright's syndrome, Basilar melanosis with incontinence, Beta thalassemia; Healed mucocutaneous lesions-Lichen planus, Pemphigus,Pemphigoid; Hereditary hemorrhagic telangiectasia; HIV-associated melanosis, Neurofibromatosis, Peutz-Jeghers and other familial hamartoma syndromes, Pyogenic granuloma /Granulomatous epulis.
X	Pigmented benign and malignant lesions involving the gingival like Angiosarcoma, Hemangioma, Kaposi's sarcoma, Malignant melanoma, Melanocytic nevus, Pigmented macule.

1.4.4 Recurrence of pigmentations

Limited information about re-pigmentation (reappearance of oral pigmentation after management) makes no definitive treatment for this condition [52], however it was believed that re-pigmentation can occur due to:

I. Migration of active melanocytes from the adjacent pigmented tissues to the treated site [82].

II. Incomplete removal of active melanocytes from the basal layer of epithelium during management using any depigmentation techniques [83].

1.5 Laser basics

The word laser is an acronym for light amplification by stimulated emission of radiation. It was first invented in 1960 by Maiman based on Einstein theories in 1916 which include that the photon can stimulate the emission of identical photon. The first application of laser in dentistry was done by Stern and Sognnaes (1964) and Goldman et al (1964) which describes the effect of ruby laser on dental hard tissues [84]. Laser light is differ from ordinary light in two important features which is monochromaticity and coherence. Laser light is monochromatic which means it is composed of single color (single wavelength) while the ordinary white light is produced by sum of many colors of the visible spectrum: red, yellow, green, blue, and violet that is why it appear white in color. The second important feature is the coherence which means that the amplitude as well as the frequency of all waves are identical. Other important features of laser light include collimation, focusability and brightness [85].

1.5.1 Component of laser device

Laser device is composed of 3 basic components [86]:

I. Active medium: The active medium is composed of an element, a molecule or a compound that could be gas like Co_2 laser, solid crystal of yttrium aluminum garnet (YAG) in Er:YAG and Nd:YAG, semiconductor like diode laser or sometimes could be liquid.

II. Optical resonators: which could be either two mirrors that are placed parallel to each other (figure 1-9) or could be two polished surfaces as in semiconductor laser. The optical resonator acts by reflecting the waves back and forth inside the laser cavity which result in amplification.

III. Pumping source: The pumping source surrounds the active medium and it is responsible of excitation of atoms or molecules of active medium. The pumping source could be either optical (like flash lamp) or electrical (like electric circuit).

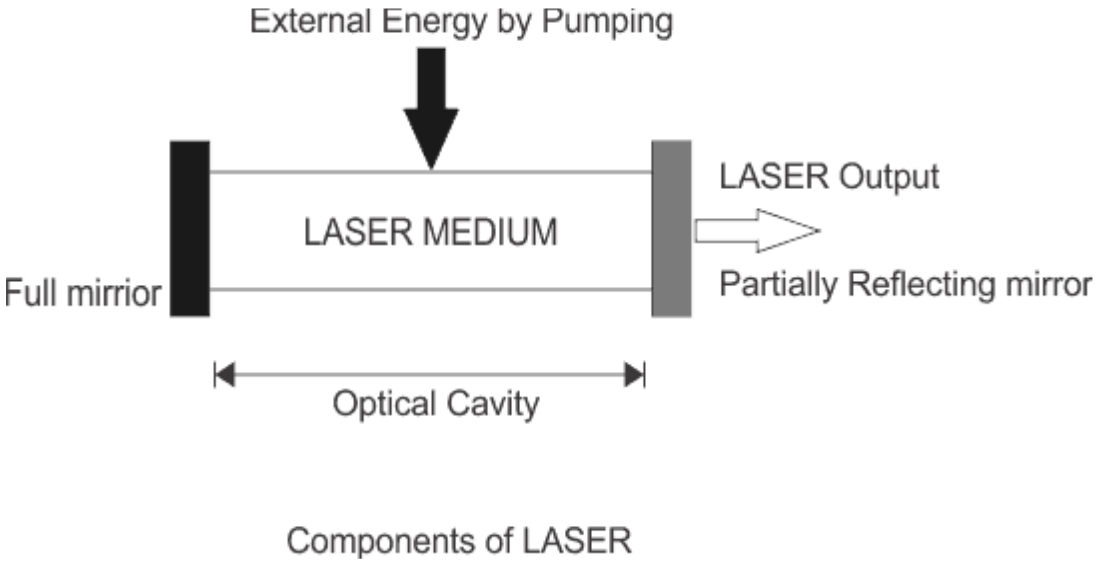

Figure 1-9: Basic component of laser cavity

1.5.2 Laser Delivery system

Each laser device has a specific delivery system depending on the wavelength of the laser itself. Lasers with a shorter wavelength (such as KTP, diode and Nd:YAG laser) can be delivered to the targeted tissue by fiberoptic which small and flexible while other lasers like (Er:YAG and CO2 lasers) cannot be delivered via fibeoptics, instead, they can be delivered via a hollow wave guide or articulated arm which are semiflexible [88]. Dental lasers can be used in contact or out of contact. In contact mode, the laser tip is in contact with the tissue, while in out of contact (noncontact) mode the laser beam is aimed from a certain distance at the targeted tissue; thus, care must be taken specially those lasers with invisible light due to the loss of tactile sensation. Lasers can

be used also in focused and in defocused mode. Lasers can be focused using lenses; thus, can be used in incision and excision while in defocused mode laser beam becomes more diverge, cover a wider area and deliver less energy, usually useful in hemostasis [86].

1.5.3 Modes of operation

Emission modes of laser could be classified into (figure 1-10):

(1) Continuous mode (CW):in this mode, the laser power is constant during time without any fluctuations.

(2) Pulsed mode: the pulsed mode can be further divided into gated pulsed and free running:

(A) Gated pulsed mode: this mode can be achieved in laser devices that operate in continuous mode by placing a mechanical shutter which can open and close in front of the beam path leading to a periodic fluctuations or alterations in laser energy like blinking of a light. In gated pulsed mode, the pulse duration usually in microsecond (μsec) or millisecond (msec).

(B) Free running pulsed mode: it is also called true pulsed mode. In this mode, the high peak energy of laser is delivered for short duration followed by long period of time in which the laser is off. The true pulsed laser depends on the actions of the pumping source itself [89]

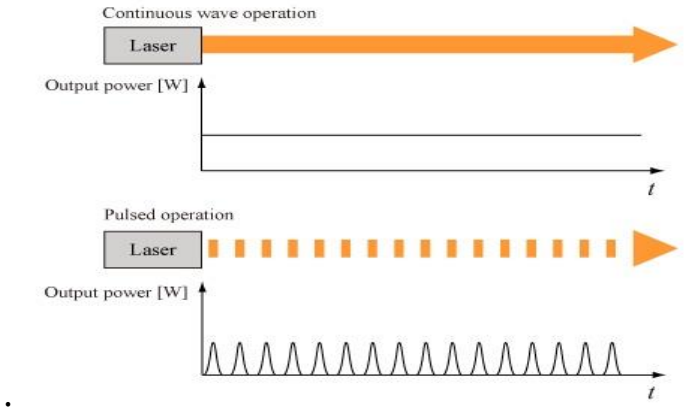

Figure 1-10: Oscillation of continuous and pulsed laser [86].

1.5.4 Laser parameters

These parameters are very important to consider when dealing with laser radiation which include [87]:

I. Wavelength λ: it is the the distance over which the wave's shape repeats, usually measured by meters (m) and it is considered a very important property because it will determine how the laser is going to be delivered into the operative site and how it will react.

II. Frequency υ: it is the number of complete oscillations of the wave per time and it is measure by hertz (Hz).

III. Pulse duration: refers to full width at half-maximum of a single pulse of pulsed laser.

IV. Peak power: it is equal to energy in Joule/pulse duration

V. Average power: it is equal to energy in Joule*pulse repetition rate

VI. Pulse repetition rate: refers to the number of pulses per time.

VII. Spot size: refers to the diameter of laser beam on the targeted tissue

VIII. Power density (Irradiance): it is equal to power in watt per unit area (W/cm^2)

IX. Energy density (fluence): it is equal to energy in joule per unit area (J/cm^2)

1.5.5 Laser tissue interactions

Laser tissue interaction can be classified into two categories:

I. Laser may exhibit one of these four behaviors when hitting tissue surface (figure 1-11) depending on the tissue optical properties (absorption, reflection and scattering coefficients) these behaviors include [90]:

:

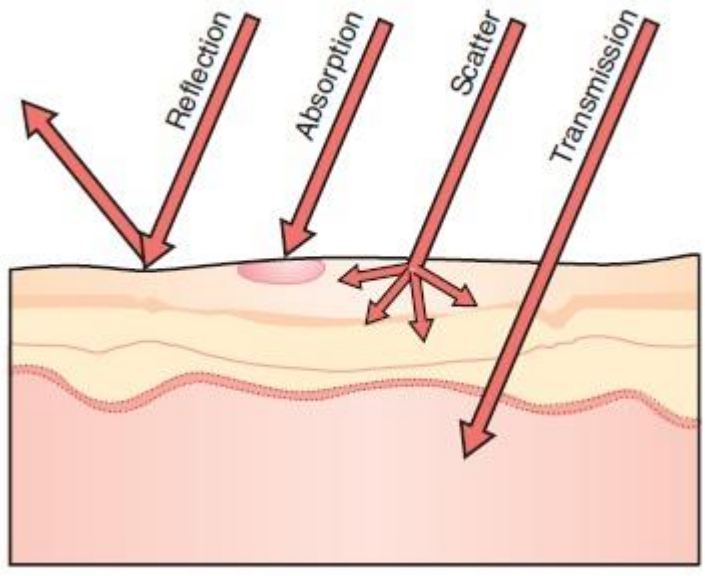

Figure 1-11: Potential laser-tissue interactions [87].

(A) Reflection

Reflection occurs when the laser light is redirected away upon hitting the tissue surface without any effect to the tissue. This effect can sometime become dangerous as the reflected laser light maybe redirected

to operator's eye and cause a significant damage. An example of reflection is the interaction of CO2 laser with titanium implants.

(B) Scattering

Scattering is redirection of the photons inside the tissue which result in increasing the absorption due to increase the chance of interacting with chromophores of that wavelength. The disadvantage of scattering is that heat will transfer into the adjacent tissue causing unwanted damage.

(C) Transmission

Transmission is the passage of laser energy through the tissue without any effect to the tissue, in another word the tissue here is transparent to the laser light, example of this interaction when diode laser or Nd:YAG laser are interact with water.

(D) Absorption

Absorption is depending on the tissue characteristics such as the presence of pigments or water inside the tissue and also depends on the laser wavelength. Figure (1-12) shows the absorption coefficient for different chromophores of oral tissues.

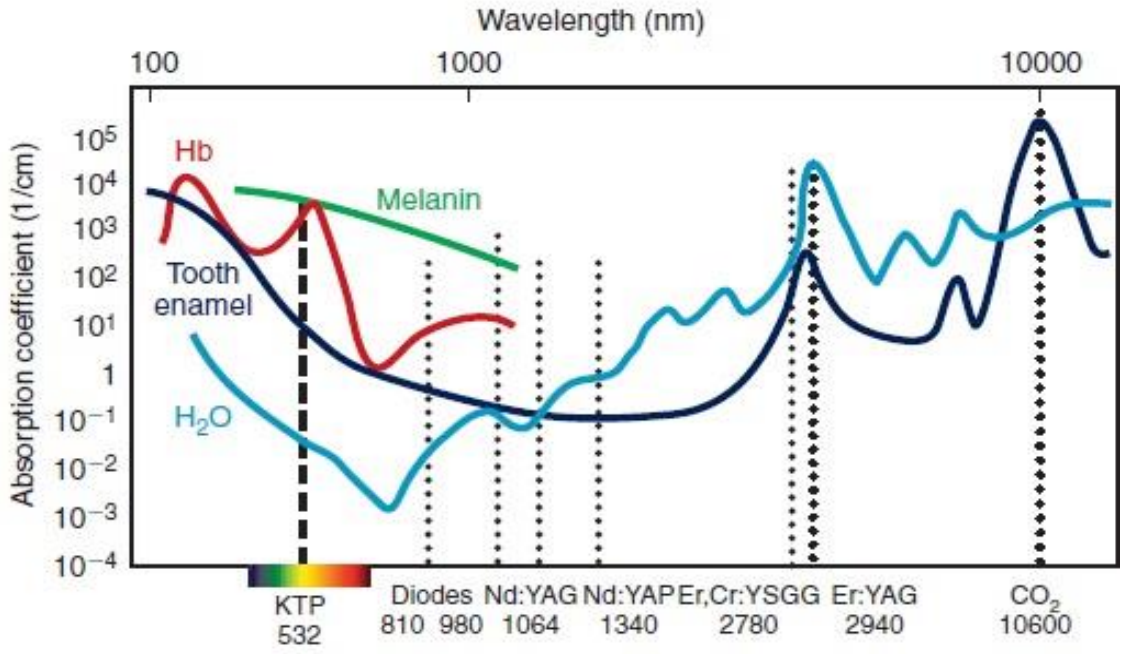

Figure 1- 12: Approximate absorption curves of the prime oral chromophores [87].

II. Laser can interact with biological tissue in two ways (figure 1-13):

A) Wavelength dependent mechanisms.

B) Wavelength independent mechanisms.

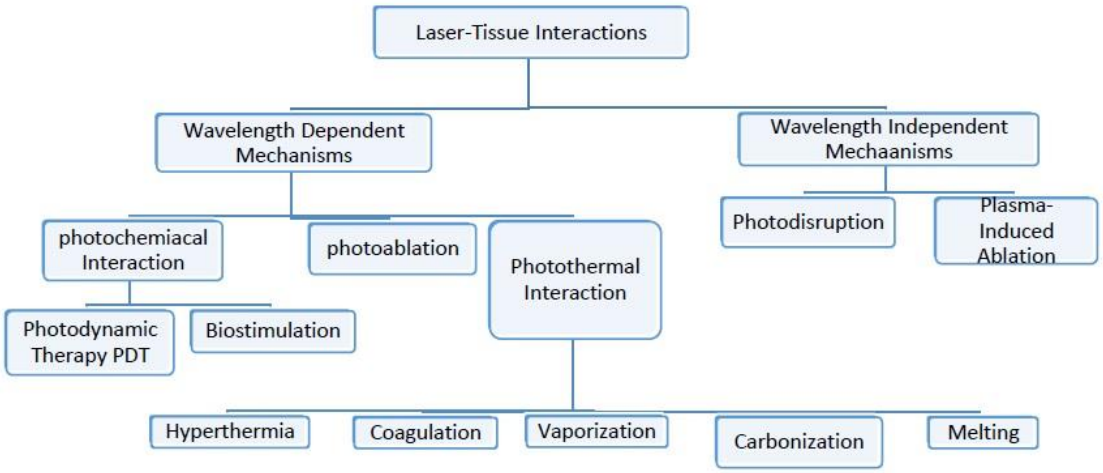

Figure 1-13: Mechanisms of laser-tissue interactions [91].

A) For Wavelength dependent mechanisms, these mechanisms include:

1) Photochemical effect

This effect usually occurs when using a very low power density and longer exposure time which result in a chemical reaction due to excitation of molecules. One application of photochemical effect is the **photodynamic therapy** which include that a special chromophore called photosensitizers are injected into the body. These chromophores are selectively absorbing laser radiation and undergoes a several decays and intermolecular transfer reactions ending in the production of a highly cytotoxic reactants that cause irreversible oxidation of cell structures (e.g. malignant tumor) [92]. Other application of photochemical effect is the **bio-stimulation**. The principle of this effect is to increase the production of adenosine triphosphate (ATP) which result in [93]:

1)Enhance repair of the tissues by increasing the production of collagen fibers and improves the microcirculation

2) Anti-inflammatory effect by increasing vessel's wall permeability and lymphatic circulation, also by decreasing the production of tumor necrosis factor (TNF) and proinflammatory interleukin which provoke the systemic effect of immune cells such as Macrophages and natural killer cells.

3)Reduce pain by increase the production of endorphin which inhibit nociceptive signals. Also decrease the pain by creating transient varicosities along the neurons and by that it will decrease impulse transmission.

2) Photothermal effect

The principle of this effect includes rise of local temperature inside the tissue, in another word the chromophore absorbs laser radiation and convert it into a heat. This effect can be induced either by CW or pulsed laser. If this rising temperature is within the human body temperature or slightly above it no noticeable reaction is observed, but if the rising temperature is above the critical point it will lead to irreversible cells damage which means that their mechanisms to repair themselves does not work anymore, that is necrosis [92]. Figure (1-14) shows the minimum critical temperature for tissues in relation with duration of temperature.

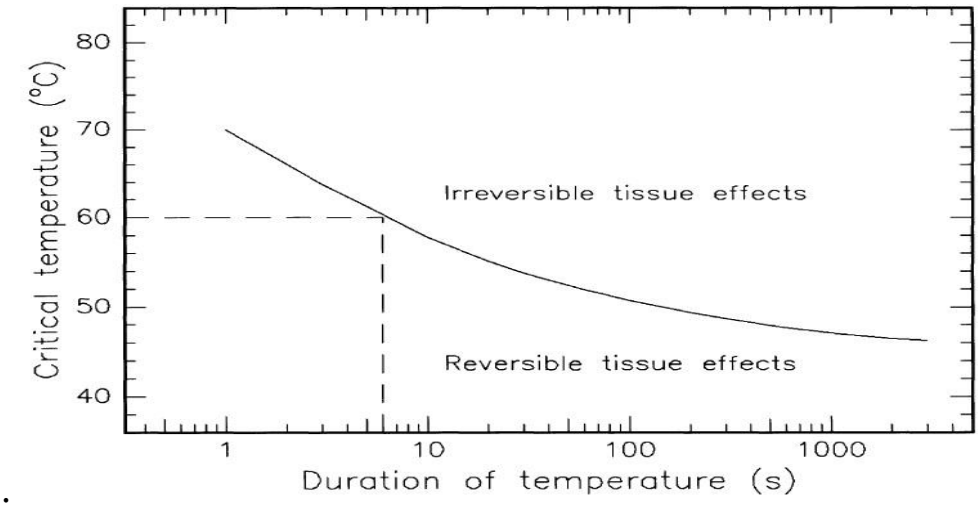

Figure 1-14: Critical temperatures for the occurrence of cell necrosis [91].

The basic physics of photothermal effect is explained by the flow chart figure (1-15):

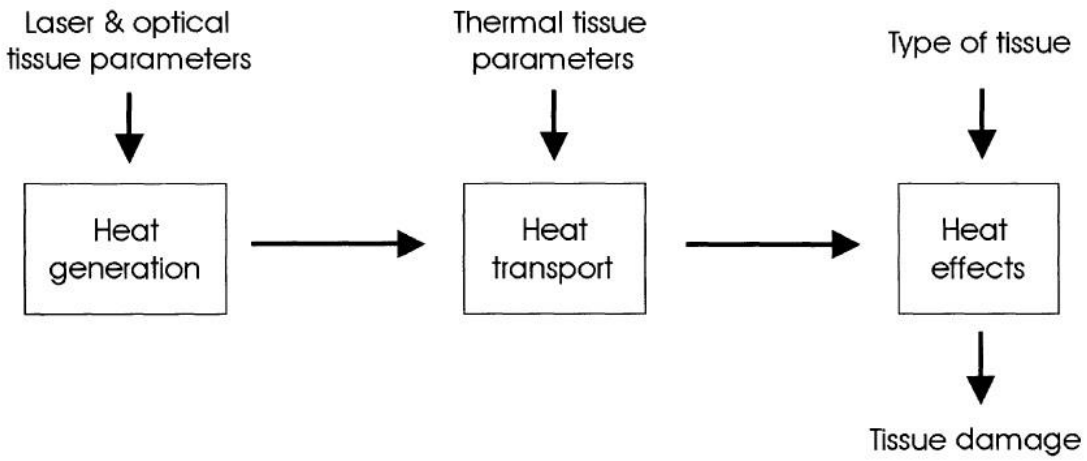

Figure 1-15: Flow chart for thermal interaction [91]

Heat generation is determined by laser parameters such as (wavelength, exposure time, spot size and intensity of laser) and also determined by optical tissue parameters such as (absorption coefficient, scattering coefficient, thermal penetration depth and relaxation time). Heat transport is determined by thermal tissue properties such as conductivity and capacity. Heat are usually transport via three ways which is either conduction, convection via blood flow or radiation. Heat effect is mainly depending on two parameters which is the type of the tissue and the value of temperature that achieved inside the tissue. Depending on the duration of the temperature, different effect will occur as can be seen in table (1-2).

Table 1-2: Thermal effects of laser radiation [91]

Temperature (°C)	Biological effect
37	Normal
45	Hyperthermia
50	Reduction in enzyme activity, cell immobility
60	Denaturation of proteins and collagen, coagulation
80	Permeabilization of membranes
100	Vaporization, thermal decomposition (ablation)
>100	Carbonization
>300	Melting

Two important parameters must be considered during photothermal effect which are [87]:

(A) Thermal penetration depth ztherm (t) which is the distance that the temperature has decreased to 1/e of its peak value. Table (1-3) shows thermal penetration depth of water in relation with time.

Table 1-3: Thermal penetration depths of water [91].

Time t	Thermal penetration depth $z_{\mathrm{therm}}(t)$
1 µs	0.7 µm
10 µs	2.2 µm
100 µs	7 µm
1 ms	22 µm
10 ms	70 µm
100 ms	0.22 mm
1 s	0.7 mm

(B) Thermal relaxation time Ttherm which is the time that needed for the tissue to loss 63% of thermal energy. Thermal relaxation time has a relationship with the pulse duration: When the pulse duration is less than the thermal relaxation time of the tissue the heat will not diffuse further and no thermal damage will occur, while if the pulse duration is more than the thermal relaxation time of the tissue it means there is not enough time for the tissue to get rid excess heat so it will diffuse further causing thermal damage.

3) Photoablation effect

This interaction is usually occur using laser with intensity between 10^7 and 10^{10} W/cm^2 and short pulse duration (in nanosecond). The principles of this effect are to break the organic molecular bonds in proteins and collagen, in order to due that the wavelength must be below 350 nm and that the energy of photon must be higher than the dissociation energy of the bonds which is usually between 3 and 7 eV. Tissue are removed by explosive manner in photoablation generating a plume from the ablative site. Photoablation in comparison with photothermal is smooth, high precision, no deep penetration depth and no thermal effects [94]. Figure (1-16) shows the principle of photoablation.

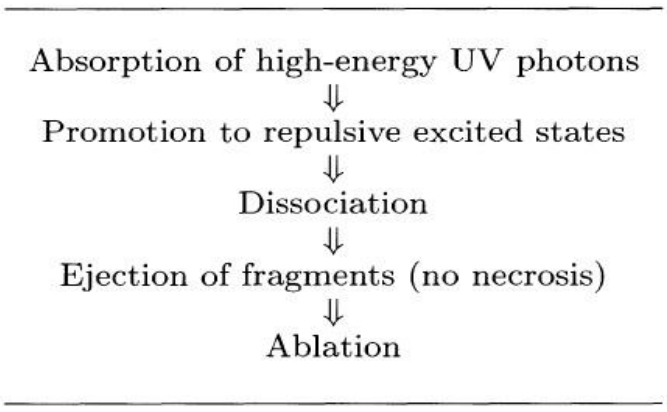

Figure 1-16: Scheme principles of photoablation [91].

B) For Wavelength independent mechanisms, these mechanisms include:

1) plasma-induces photoablation

This interaction is characterized by optical break down phenomenon which occur when intensity of laser is above 10^{11} W/cm^2 with a short pulse duration. This phenomenon is accompanied by plasma formation and a sparking noise. Optical breakdown occurs in two steps:

(A) Multiphoton ionization which include the generation of free electrons by nonlinear absorption. The rate of multiphoton ionization is proportions to the intensity of the laser [91].

(B) Avalanche ionization: the generated free electrons are accelerated by absorbing any photon energy, so after multiple photons absorption they will gain more kinetic energy and collides with other molecules creating more free electrons. Avalanche effect occurs when the laser intensity is high enough to cause rising in free electrons density in the order of picoseconds for a very time, this will result in a cloud of ions and free electrons, that is plasma. Plasma-induced ablation usually occur when pulse duration in femtosecond, so the interaction is extremely short and the tissue is removed by thermal vaporization within the volume of the plasma due to the high temperature of the plasma and chemical dissociation by electrons [95]. In another word, the ablated area is kept confined within optical breakdown region that is why Plasma-induced ablation produced a very clean and well-defined removal of tissue without any thermal and mechanical damage.

2) Photodisruption

Photodisruption is differ from plasma-induced ablation in that the pulse duration is in picosecond or nanosecond, so the optical break down is high here. In addition to plasma formation the optical break down is accompanied by a popping sound which indicates that chemical reactions are occurs. When these reactions dominate, photodisruption will occurs which is characterized by:

(A) Shock wave: a destructive shock wave is generated by expanding of plasma radially. This shock wave will push the surrounding tissue away from it's center causing it to rupture by shear forces [95].

(B) Cavitation: When the tissue is evaporated by the action of plasma temperature, the generated vapor of water and carbon dioxide are usually higher than the atmospheric pressure, so the vapor will push the surrounding tissue away leading to cavitation. The cavitation bubbles are then collapse near solid boundaries creating jet formation. The volume of the cavitation is usually corresponding to the volume of the removed tissue [96]. Figure (1-17) shows a plot of laser tissue interaction.

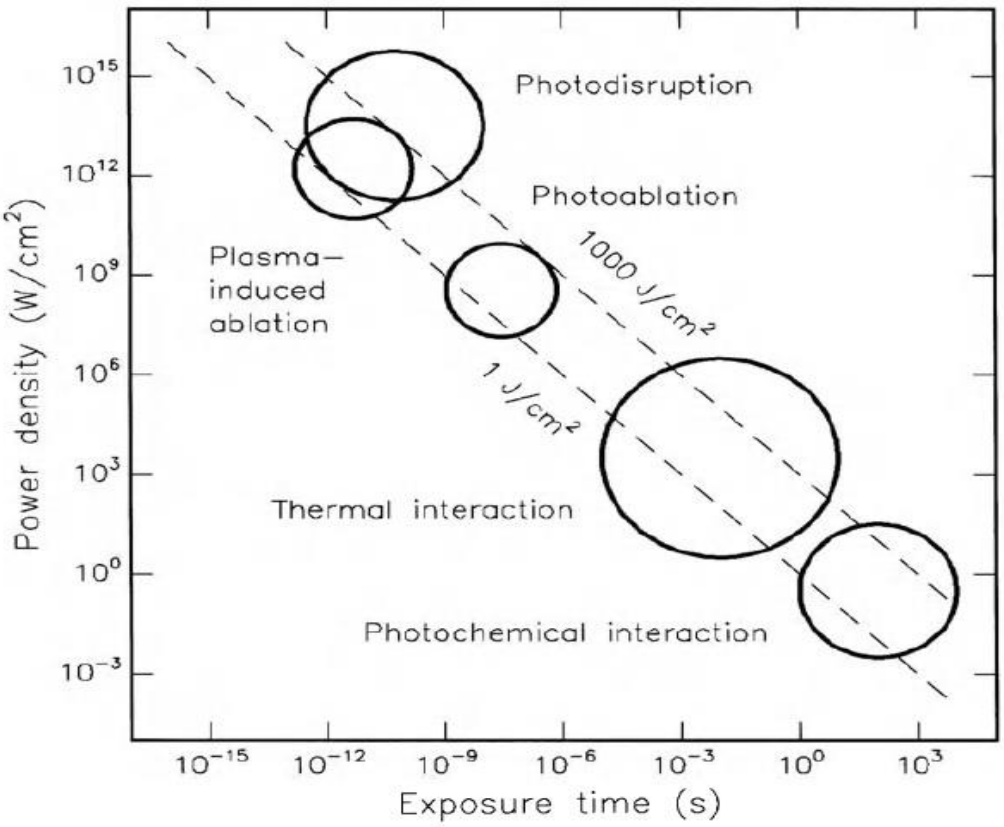

Figure 1-17: Map of laser–tissue interactions mechanisms. The relationship between power density and exposure time produces a various photobiological effects [91].

1.6 Laser safety guidelines

1.6.1 Laser hazard classifications

Lasers are classified into [97]:

Class 1 laser system

Any laser system that emit laser radiation without causing any injury to skin or eye during normal operation.

Class 1M laser system

These lasers are incapable of producing any hazards and it should not be viewed by a collecting optics.

Class 2 laser system

Visible lasers with low power that do not cause eye hazard because of aversion response of human eye (blinking of the eye), some time it can cause a potential eye hazard if its viewed directly for a period of time.

Class 2M laser system

Visible lasers with low power that are incapable of producing any eye hazards unless viewed by a collecting optics.

Class 3R laser system

Laser system that can cause an injury to the human's eye if it is viewed directly for a short period, but also can cause a greater eye hazard if it is viewed by a collecting optics.

Class 3B laser system

Visible or invisible medium power lasers that can cause a potential eye hazard for direct viewing and specular reflection conditions. Normally, diffuse reflection can not cause any eye hazards.

Class 4 laser system

Visible or invisible high-power lasers that can cause skin and eye hazards when viewed directly as well as specular and diffuse reflection. They are also capable of producing fire hazard.

1.6.2 Nominal ocular hazard distance (NOHD) and nominal hazard zone(NHZ)

NOHD is the distance within which the laser can cause an eye damage if the beam directed to the eye. Figure (1-18) shows the potential eye damage in relation to wavelengths. Each laser model has a specific

NOHD. NHZ is the area within the nominal ocular hazards distance (NOHD). NHZ should be allowed only for the patient and necessary persons. NHZ should be designated with appropriate signs that contains laser classification, wavelength, laser power and its potential danger, also all reflective surfaces should be avoided or minimized within NHZ. Each person within NHZ must wear an eye protection. The design of the protective eye wear requires an optical density (OD) and laser filtration for the wavelength being used in nanometers to provide a proper eye protection. All class 3B and 4 requires a protective eye wear [97].

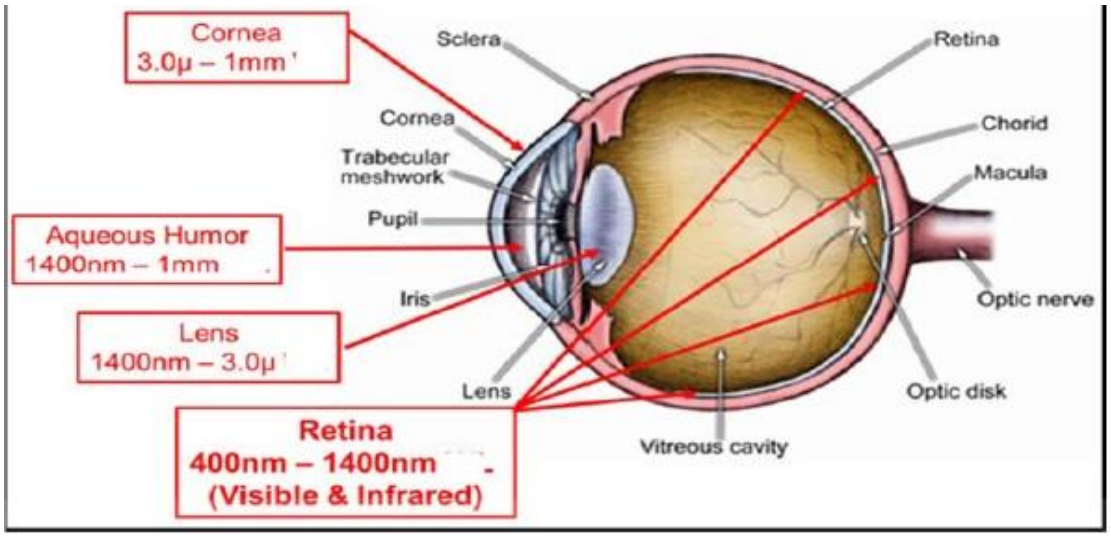

Figure 1-18: Potential eye damage according to laser energy [97].

1.6.3 Warning signs of laser control area

These signs include [97]:

"DANGER" which indicate an extremely hazardous situation that can cause death or serious injury if it's not avoided. This sign is restricted to class 4 laser with high output power.

"WARNING" indicates hazardous situation that can lead to death or serious injury (fig. 1-19), it is restricted to class 3B and 4 lasers.

"CAUTION" indicates hazardous situation that can lead to minor or moderate injury, it is restricted to class 2 and 2M lasers.

"NOTICE" indicates practice that does not cause any injury.

Each one of these signs must have the laser classification, output power and wavelength of laser being used

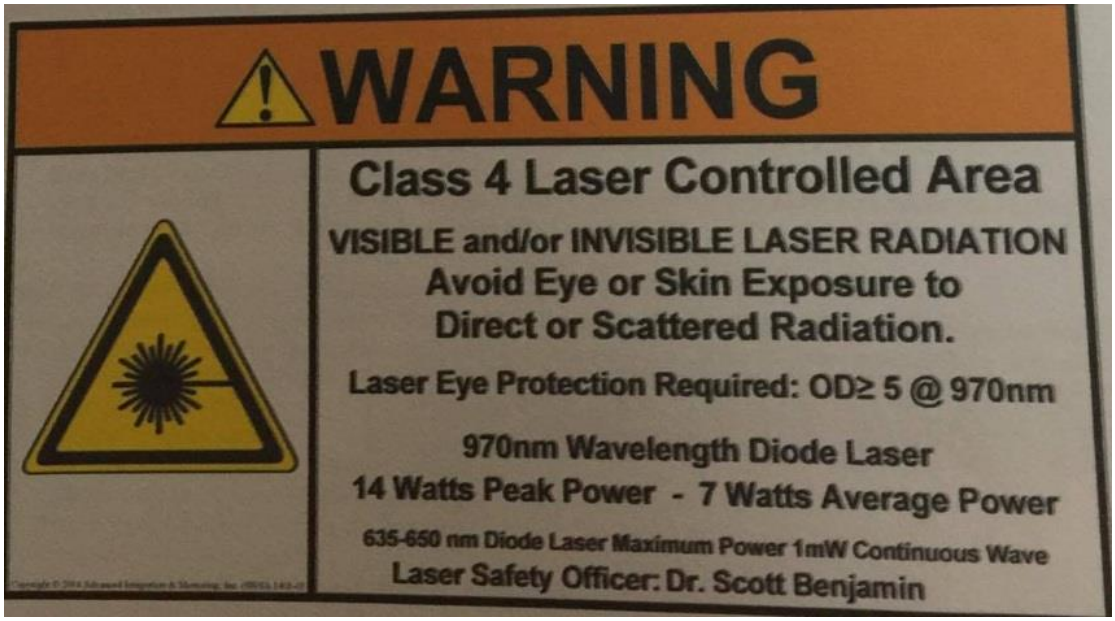

Figure 1-19: Sample of warning sign for class 4 laser control area [97].

1.6.4 Laser hazards

These hazards include [97]:

(A) Respiratory hazards

When the laser interacts with tissue, a laser plume is generated, which is usually a fume of gas formed when the tissue is ablated and can usually contain microorganisms and other hazardous particles. Many precautions have been considered in order to reduce or to remove laser plume include:

high volume evacuation to remove the plume from the operated site, water irrigation to reduce the plume and the use of well fitted surgical masks.

(B) Fire hazards

Any combustible material such as oxygen, nitrous oxide and alcohol should be avoided, also any flammable material like paper tray cover or dental gauze must be placed away from the hot fiber tip of the laser

(C) Electrical hazards

Electrical cables and cords must be in a good condition, also electrical connections should be properly grounded.

(D) Chemical hazards

Laser such as excimer laser uses materials that are hazardous and contain a highly toxic substance, so a proper precaution should be taking when dealing with these lasers.

1.7 Literature review

A lot of depigmentation method have been used each one has its own advantages and disadvantages:

For scalpel method, this method includes excision of the pigmented epithelium with the underlying connective tissue that support the epithelium. This method doesn't consider as a permanent result because in all cases that are treated relapse will occur in 36 months [98]. Dixit, A. and Dixit, S. (2012) [8], Shah, S.S. (2012) [99] and Kanakamedala et.al (2010) [100] uses a scalpel method for depigmentation and found that it's simple, easy to perform and cost effective also wound healing is faster than in other methods, but this method causes unpleasant bleeding during and after the surgery and also requires a periodontal dressing to cover the exposed lamina propria for 7-10 days [101].

For depigmentation using dental bur, this method includes the use of a large dental diamond bur (2 mm or 2.5 mm in diameter) accompanied with copious water lavage in brushing like strokes to remove all of the pigmented epithelium [102]. Small size burs are not recommended since it will create small pits and surface irregularities. Alqahtani, S.M (2015) [9], Prasad, S.S.V. et al (2010) [103] and Mokeem, S.A (2006) [104] have used bur method in depigmentation and found that it is simple method, the technique is easy to perform, cost effective, more patient satisfaction, less painful, tissue removal is minimal and that the technique itself is comfortable for the operator and the patient while the disadvantages of this method include: bleeding, care must be taken for the bur's speed as well as the applied pressure when using this method. Pitting of gingival tissue may result from holding the bur in one position for a longer time [105].

For depigmentation using cryosurgery a liquid nitrogen or Tetrafluoroethane spray have been used which applied first on a cotton swab and immediately rolled over the pigmented gingiva which result in destruction of gingival epithelium along with melanocytes. Kumar, S. et al (2013) [7] and Singh,V. et al (2012) [106] have used Tetrafluoroethane in depigmentation and they are found that it is simple, inexpensive, also it is application with a cotton swab is easy to perform, the wound heals rapidly ,mild pain and absence of bleeding. The disadvantages of this method include cross-contamination is possible, depth control is difficult and increases the risk of tissue destruction. No relapse has been observed for 34 months using this method [107].

For depigmentation using electrosurgery a molecular disintegration of melanocyte cells occurs a long with the surrounding sites due to the use of electric energy. Gokhale, S.T. et al (2011) [11] and Bhusari, B.M. and Kasat, S. (2011) [108] have used electrosurgery in depigmentation and found that the advantages of this method include minimal bleeding occur in the operation site, cleaner surgical sites and also minimal patient discomfort while the disadvantages include that heat accumulation and tissue destruction occur due to repeated and prolonged use of electrosurgery; thus, it requires more experience [99].

For depigmentation using lasers, a lot of lasers have been used for depigmentation method these are includes: diode laser, Nd:YAG laser, Er:Yag laser, Er:Cr:Ysgg laser and Co2 laser. Doshi, Y. et al (2012) [12] have used diode laser (940 nm) with initiated tip to remove the epithelial layer for depigmentation purpose, Ko, H.J. et al (2010) [5] have used Nd:YAG laser (1064 nm) which has high absorption in melanin pigments ;thus, removing the pigmented tissue easily, Rathod, D.M. and Mulay, S. (2013) [3] have used Er:YAG laser (2,940 nm) , Kusakcİ Seker, B.

(2017) [13] has used Er:YSSG laser (2,780 nm) and Mahdi A.S. and Noor T.I. (2013) [14] have used Co2 laser (10600 nm). The later three lasers (Er:Yag,Er:YSSG and Co2 laser) have a high absorption in water ;thus, removing the epithelial soft tissue by vaporization the water content of tissue. The advantages of using laser includes bloodless fields with diode and Nd:YAG lasers and minimal bleeding with the other lasers, minimal swelling, no mechanical trauma, better healing ,reduces the operative time , no periodontal dressing is needed ,sterilization effect of lasers and high patient acceptance. The disadvantages are that this method is much more expensive and requires experience.

1.8 Aim of the study

To compare between 940 nm diode laser and conventional bur method in management of gingival hyperpigmentation.

Chapter Two
Materials and Methods

Chapter two

Materials and methods

This chapter describes the materials and methods used in the study.

2.1 Materials

- Dental syringe
- Anesthetic carpul (2.2 ml carpul containing 2% lidocaine with epinephrine 1:80.000, France).
- Disposable dental needle
- Cheek retractor
- Suction tube
- Normal saline
- Gauze
- Mirror, tweezer and probe.
- Disk diamond bur (4 mm)
- Dental turbine.
- Cotton rolls
- Hemostasis solution (Switzerland). (Composition: Tannic Acid 25%, Chlorobutanol hemihydrate 1.6%, excipient ad 100%)
- Diode laser 940 nm (Epic^{TM}, Biolase, USA) with additional accessories include:
    - Goggles for eye protection.
    - Initiation kit for tip activation.
    - Disposable end firing tips (400 µm).

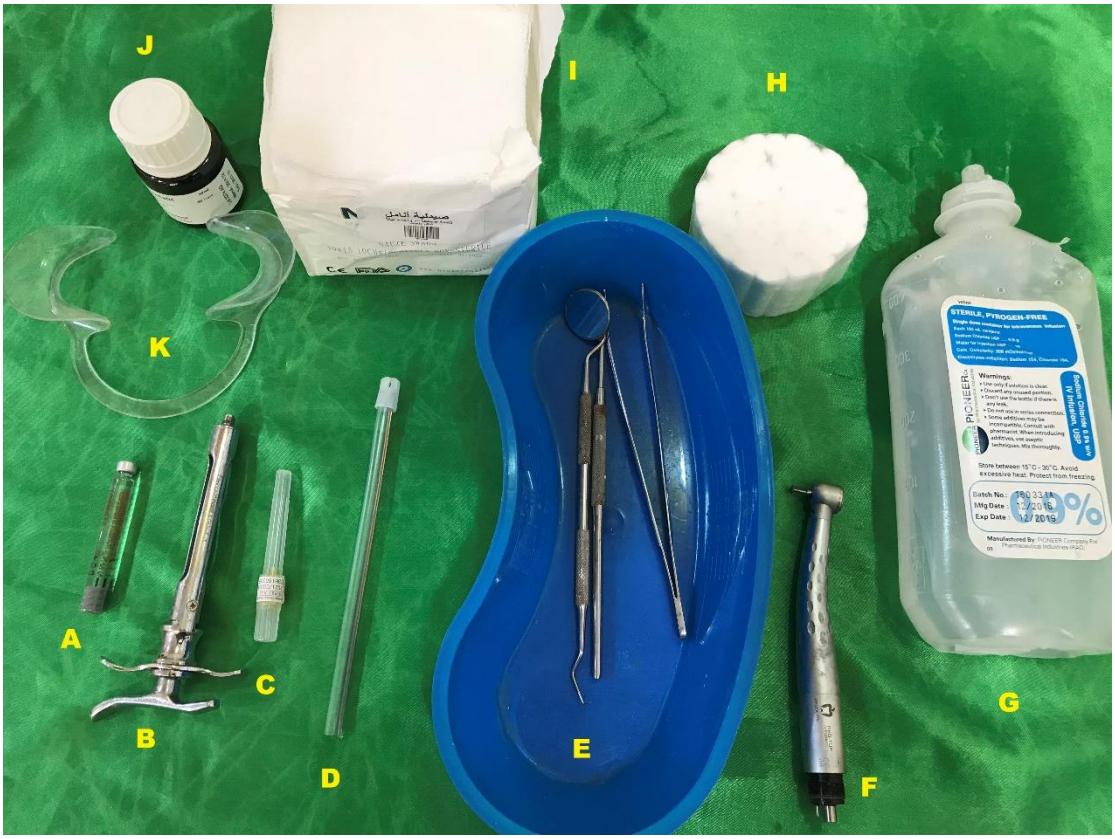

Figure 2-1: Dental equipment for conventional depigmentation procedure. (A) dental anesthetic carpul. (B) dental syringe. (c) disposable needle. (d) suction tube. (e) mirror, probe and tweezer. (f) dental turbine. (g) normal saline. (h) cotton rolls. (i) gauzes. (j) hemostatic solution. (k) cheek retractor.

Figure 2.2: (A) hemostatic agent. (B) dental disk bur used during the procedure.

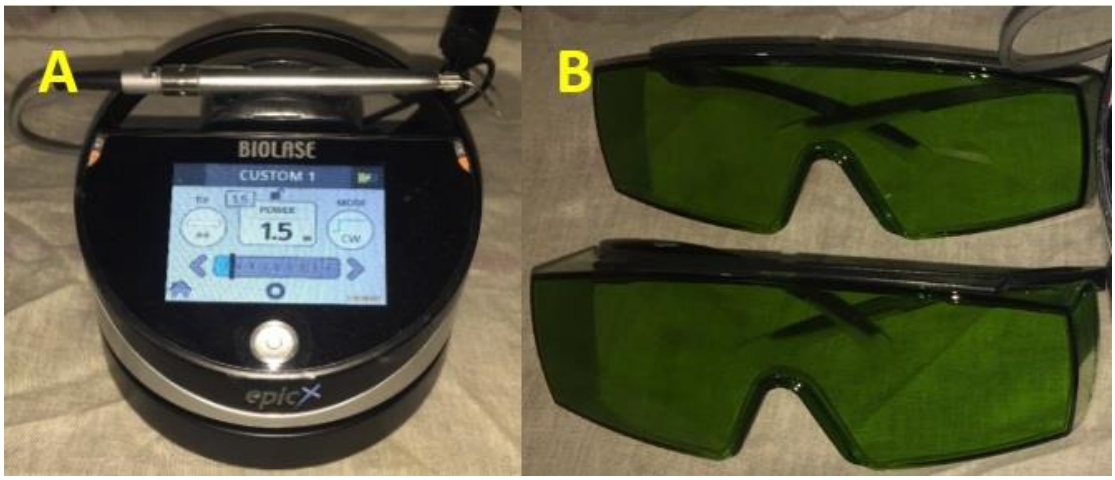

Figure 2-3: (A) Laser device. (B) eye goggles for protection

Figure 2-4: Initiation kit for laser tips

2.2 Laser system specifications

Diode laser have the following specifications:

- ❖ Laser classification: IV
- ❖ Wavelength: 940 ±10 nm.
- ❖ Medium: InGaAsP Semi-conductor diode.
- ❖ Maximum output power: 10W.
- ❖ Power accuracy: ± 20%
- ❖ Power mode: continuous and pulse

- Screen console.
- Lithium ion battery.
- Fiber optic delivery system.
- Surgical tips (200, 300 and 400 µm)
- Protective eyewear.
- Tip initiation kit.
- Wireless footswitch.
- Surgical handpiece.
- Aiming Beam: diode laser, max 1 mW, 625 nm – 670 nm, Class 2
- NOHZ: 4.77 meters.

2.3 Patients selection

Eighteen patients with physiological gingival hyperpigmentation were selected for the study (3 males and 15 females) aged between 12-36 years old. The selected patients were nonsmokers and healthy without systemic conditions or under treatment using medications. All patients have accepted the management for their pigmentation after a detailed explanation of the treatment plan and they have signed on a consent that they are willing to going through the procedure. On the day of the procedure, two case sheets were recorded for each patient, one of them was used to record the medical and dental history as well as gingival pigmentation index (by Kumar S 2012) [81] while the other one was used to evaluate pain, discomfort, bleeding, healing, re-pigmentation, duration of the procedure and functions. Some of these parameters were recorded during the procedure while others were recorded after the procedure. Only the upper gingiva was treated in this study using laser method for the right half and conventional method for the left half. the procedure was done in a private clinic with a single visit for both methods.

(Patients information)

Patients	Age	Sex	History of pigmentation	Pigmentation Score using pigmentation index
1	36	Female	Unknowm	3
2	20	Male	Unknown	3
3	20	Female	Unknown	3
4	20	Female	Since 13 years old	3
5	35	Male	Since 24 years old	3
6	18	Female	Unknown	3
7	12	Female	Since 7 years old	3
8	23	Female	Since birthday	3
9	27	Female	Unknown	3
10	22	Female	Since birthday	3
11	16	Female	Since 3 years old	3
12	16	Female	Since 10 years old	3
13	23	Female	Since birthday	3
14	18	Female	Since 16 years old	3
15	20	Male	Since birthday	3
16	15	Female	Since 7 years old	3
17	24	Female	Unknown	3
18	24	Female	Unknown	3

Gingival pigmentation scores: (Kumar S. 2012) [81]

• Score 0: Absence of pigmentation

• Score 1: Spots of brown to black color or pigments.

• Score 2: Brown to black patches but not diffuse pigmentation

• Score 3: Diffuse brown to black pigmentation, marginal, and attached

2.4 Laser procedure

First, local injection anesthesia was given to the operative site (upper right central incisor to 1st right premolar). Next, goggles were worn by the

patient and the operator for eye protection, then cheek retractor was used to expose the surgical site. Dental mirror or any metallic instruments were avoided. The parameters of the laser device were including:

- Power: 1.5 W.
- Operation mode: CW (continuous wave mode).
- Diameter of the tip: (400 μm).

After that, the laser tip was initiated using initiation kit. The depigmentation procedure was started by applying laser tip into the pigmented gingiva in brushing like strokes around all pigmented areas of the surgical site. Wet gauze was used to wipe tissue debris from laser tip and from the surgical site. The procedure was ended when all the pigmented areas of the operative site were removed. No periodontal dressing was used to cover the surgical site.

2.5 Conventional bur procedure

Local injection anesthesia was given to the operative site (upper left central incisor to the 1st left premolar), then cheek retractor was used to expose the surgical site. Suction tube was used for water evacuation. The procedure was started by using disk diamond bur (4 mm) accompanied with copious water leverage which was placed perpendicular to gingiva. The pigmented gingiva was removed by abrasion. Carful is taken during the procedure to avoid accidentally hitting tooth structures, gingival margins were also avoided. When the pigmented areas of the surgical site were removed, normal saline was used to wash the surgical site, also Hemostasis was achieved by using a gauze soaked in anesthetic agent (hemostatic solution) accompanied with firm pressure for about (3

minutes). After achieving hemostasis, the surgical site was left expose without using periodontal dressing.

2.6 Post-operative instructions

All patients were instructed to perform their normal function post-operatively. Crunchy, spicy and acidic food were avoided during the 1st 3 days of the procedures. Gentle tooth brushing was instructed to perform. Chlorhexidine mouth wash was prescribed (twice daily) for about one week. Medications include analgesic (Acetaminophen 500 mg) were prescribed for the patients and they are instructed to take their medications on need only (if the pain was severe and intolerable). After that all patients were asked for a recall visit to follow up their conditions after 3 days, 1 week, 1 month and after 6 months.

2.7 Intraoperative and postoperative variables assessment

The purpose of the study was to compare between bur and laser method in depigmentation, so during this comparison the following variables were assessed:

I) Intraoperative bleeding which was assessed using the following score [109]:

- Score 0: None
- Score 1: Self-limiting
- Score 2: Requiring light pressure
- Score 3: Requiring coagulation + pressure
- Score 4: Requiring ligation or hemoclip

II) Duration of the procedure for each side (left and right).

III) Intraoperative discomfort.

IV) Post-operative pain which was evaluated using visual analog scale (VAS) [110].

V) Post-operative healing which is evaluated using the following index:

Score 0: Very poor	I. Gingival color: about 25% or less than that is red II. Presence of granulation tissue III. Bleeding on palpation
Score 1: Poor	I. Gingival color: about 50% or less than that is red II. Presence of granulation tissue III. Bleeding on palpation
Score 2: Good	I. Gingival color: about 50% or less than that is red II. Presence of granulation tissue III. No bleeding on palpation
Score 3: Very good	I. Gingival color: about 75% or less is red II. No granulation tissue III. No bleeding
Score 4: Excellent	I. Gingiva is completely pink II. No granulation tissue III. No bleeding

VI) Medications

VII) Functions like (eating and speaking) were also evaluated postoperatively.

VIII) Re-pigmentation (recurrence of pigmentation) which was evaluated using the following score:

- Score 0: No recurrence
- Score 1: Slight recurrence.
- Score 2: Moderate recurrence.
- Score 3: Heavy recurrence.

2.8 Statistical Analysis

Data description, analysis and presentation were performed using Statistical Package for social Science (SPSS version 21). Level of significance as: Not significant $P>0.05$, Significant $P<0.05$, highly significant $P<0.01$.

Chapter Three
Results, Discussion and Conclusions

Chapter three

Result, discussion and conclusion

3.1 Results

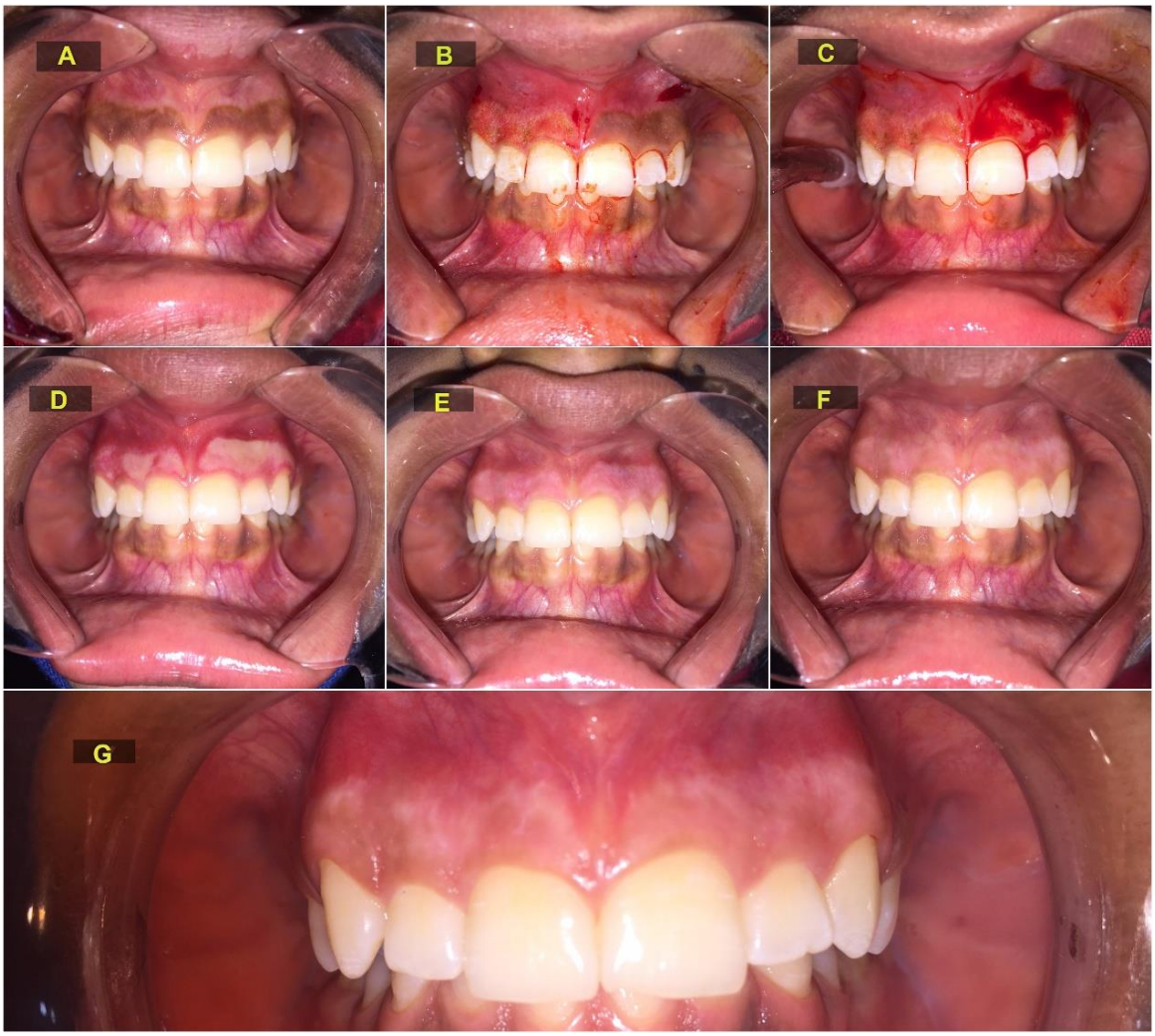

Figure 3-1: Depigmentation procedure (1). A) Before treatment. B) Immediately after laser procedure. C) Immediately after conventional bur procedure. D) After 3 days. E) After one week. F) After one month. G) After 6 months.

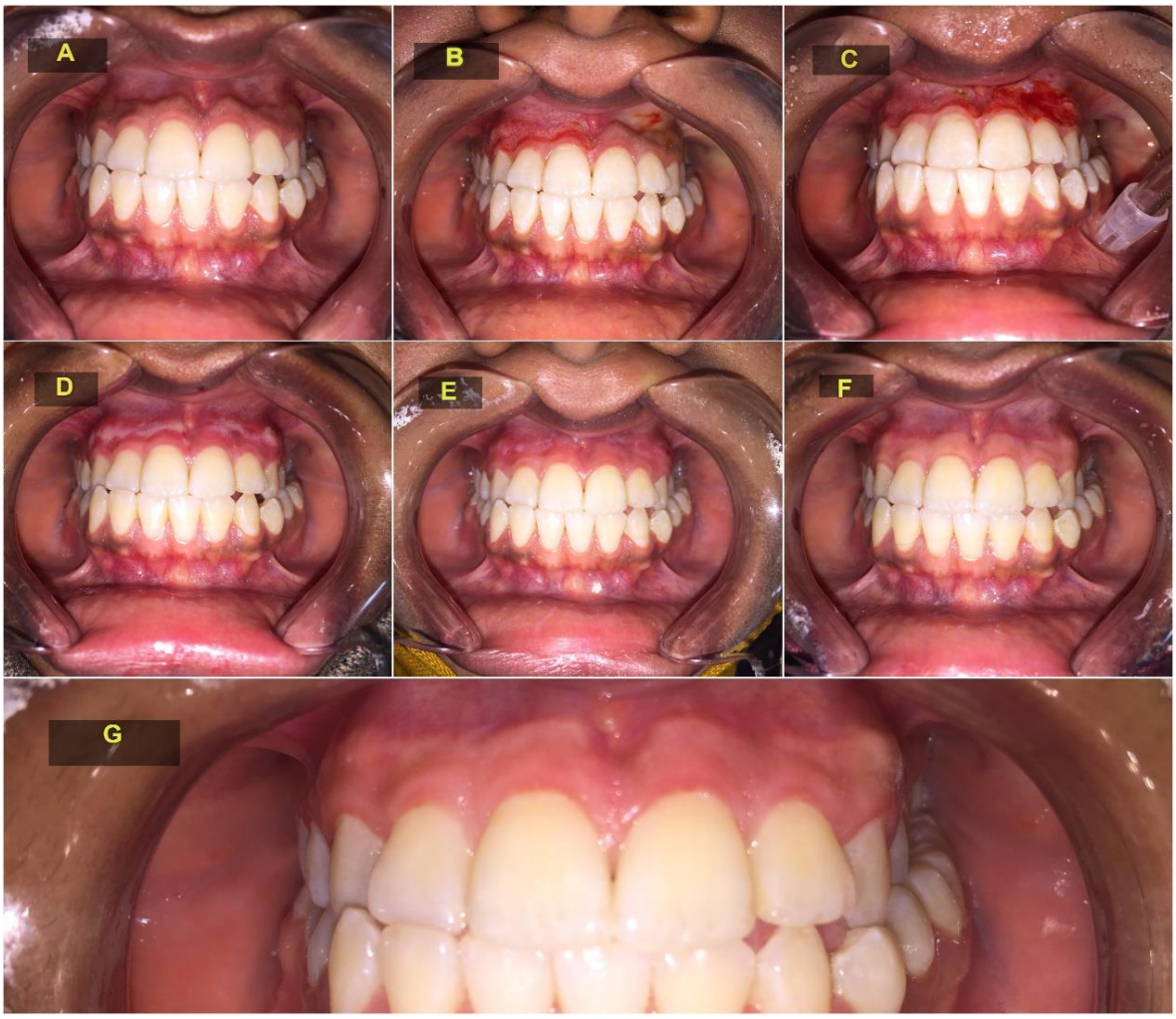

Figure 3-2: Depigmentation procedure (2). A) Before treatment. B) Immediately after laser procedure. C) Immediately after conventional bur procedure. D) After 3 days. E) After one week. F) After one month. G) After 6 months.

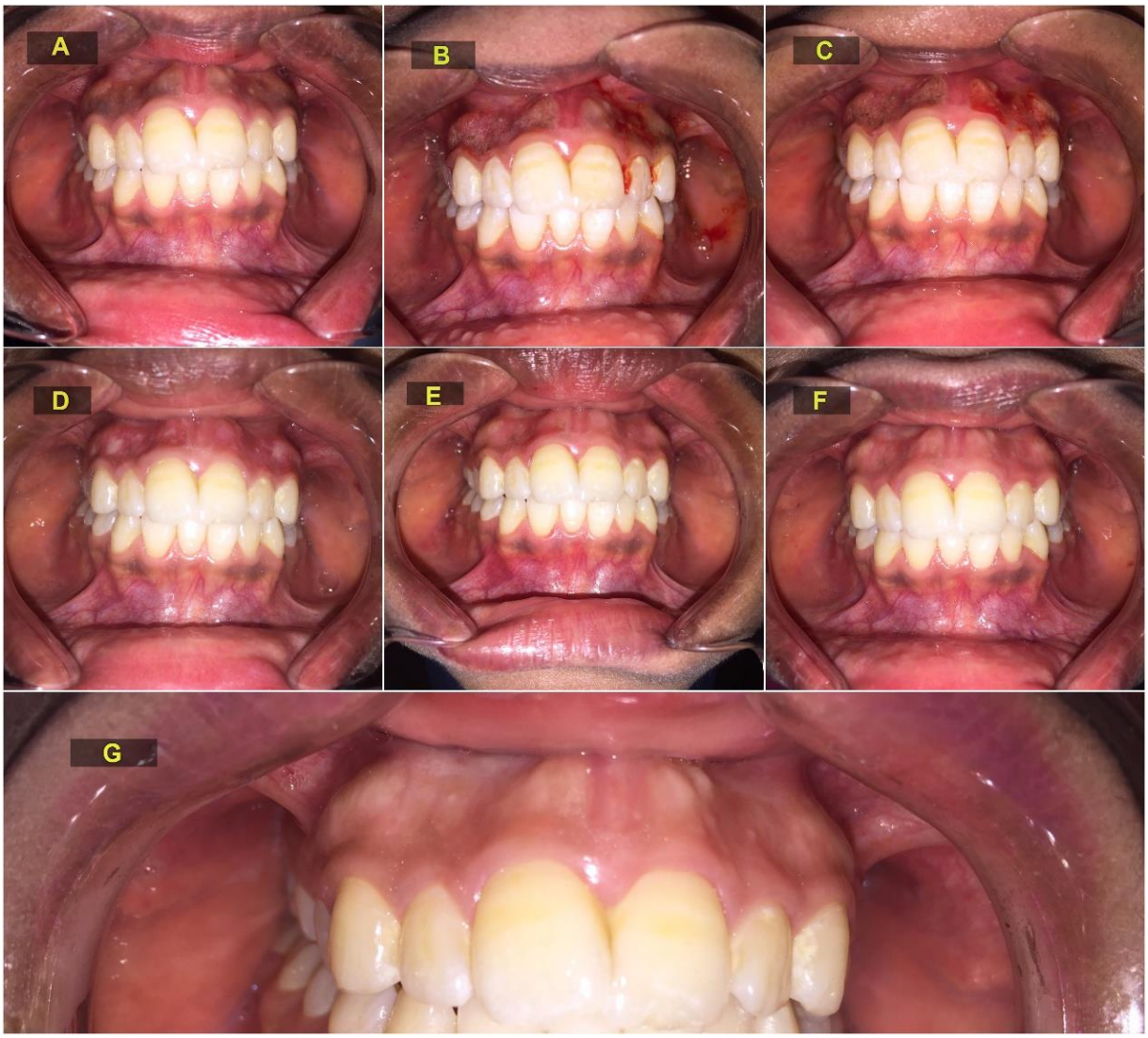

Figure 3-3: Depigmentation procedure (3). A) Before treatment. B) Immediately after laser procedure. C) Immediately after conventional bur procedure. D) After 3 days. E) After one week. F) After one month. G) After 6 months.

3.1.1 Pain

Pain was evaluated using visual analog scale (VAS) which is answered by the patients after day 1, 3 days and a week postoperatively for both methods. No pain was recorded by the patients during the procedure because all of them were anesthetized using injectable local anesthesia, but after day 1 to 3 days postoperatively, A highly significant difference in pain was observed among conventional group while a significant difference was observed in laser group as shown in table 3-3, the median of pain score can be seen in fig. (3-4). Table (3-1) and (3-2) shows the development and intensity of pain after day 1 and 3 days postoperatively. After 1 week postoperatively, no pain was observed in both sites.

Table 3-1: Intensity of pain after day 1

Surgical site	Pain using (VAS) 0----------5----------10 0= no pain 5= moderate pain 10=sever pain			
	No Pain	Mild (1-4)	Moderate (5-7)	(Sever 8-10)
Conventional site	3 over 18	4 over 18	7 over 18	4 over 18
Laser site	15 over 18	3 over 18	0	0

Table 3-2: Intensity of pain after 3 days

Surgical site	Pain using (VAS) 0----------5----------10 0= no pain 5= moderate pain 10=sever pain			
	No Pain	Mild (1-4)	Moderate (5-7)	(Sever 8-10)
Conventional site	8 over 18	8 over 18	2 over 18	0
Laser site	18 over 18	0	0	0

Table 3-3: Descriptive and statistical test of pain

Group	Statistics	Day 1	3 days	1 week	Quade test	Sig.	Multiple comparisons P-value		
Conventional	Mean	4.611	1.778	.000	36.363	0.000 HS	1 day	3 days	**0.000**
	SD	2.725	1.987	.000			1 day	1 week	**0.000**
	Median	5.000	1.500	.000			3 days	1 week	**0.003**
	Minimum	.000	.000	.000					
	Maximum	9.000	6.000	.000					
	Weighted Mid ranks	165	-25	-140					
Laser	Mean	.556	.000	.000	3.39	0.045 S.	1 day	3 days	**0.031**
	SD	1.294	.000	.000			1 day	1 week	**0.031**
	Median	.000	.000	.000			3 days	1 week	**1.00**
	Minimum	.000	.000	.000					
	Maximum	4.000	.000	.000					
	Weighted Mid ranks	51	-25.5	-25.5					
Two sample KS	Z	2	1.667	0					
	P-value	0.001	0.008	1.00					

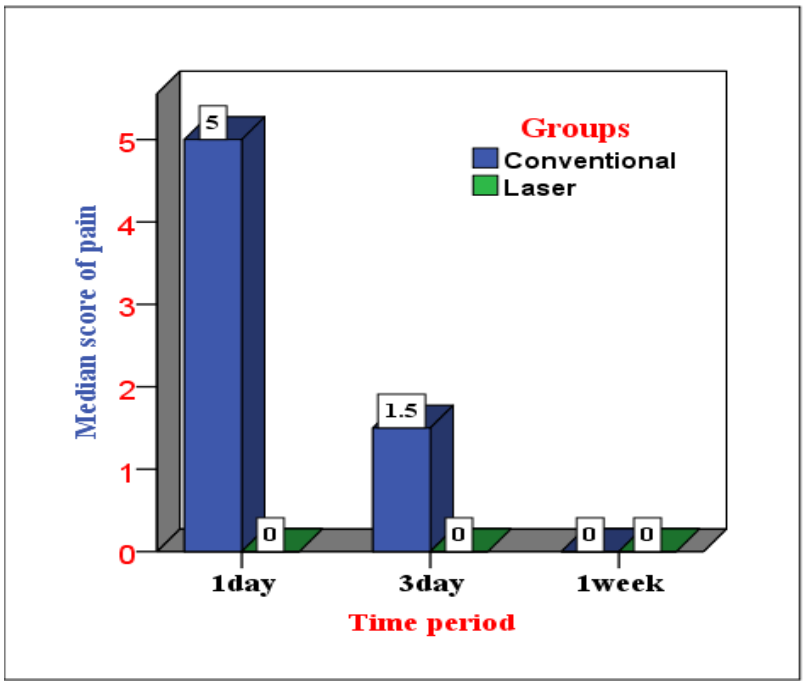

Figure 3-4: Median of pain score

3.1.2 Discomfort

Discomfort was evaluated by the patients, all the patients did not prefer the conventional method because a continuous water irrigation was used during the procedure, vibration by the turbine disk bur, suction tube which was used for water suction, also the sound of turbine and the technique itself makes them fells uncomfortable. These requirements were absent in laser procedure; thus, it was preferred by all patients. A highly significant association was observed in discomfort between laser and conventional groups as shown in table (3-4), the distribution of discomfort can be seen in fig. (3-5)

Table 3-4: Association between Discomfort status and groups

Status	No & %	Group		Total	Chi-square	df	Sig.
		Conventional	Laser				
With discomfort	NO.	18	0	18	36.00	1	0.000 HS
	% with discomfort	100.00	.00	100.00			
	% within Group	100.00	.00	50.00			
	% of Total	50.00	.00	50.00			
Without discomfort	NO.	0	18	18			
	% without discomfort	.00	100.00	100.00			
	% within Group	.00	100.00	50.00			
	% of Total	.00	50.00	50.00			

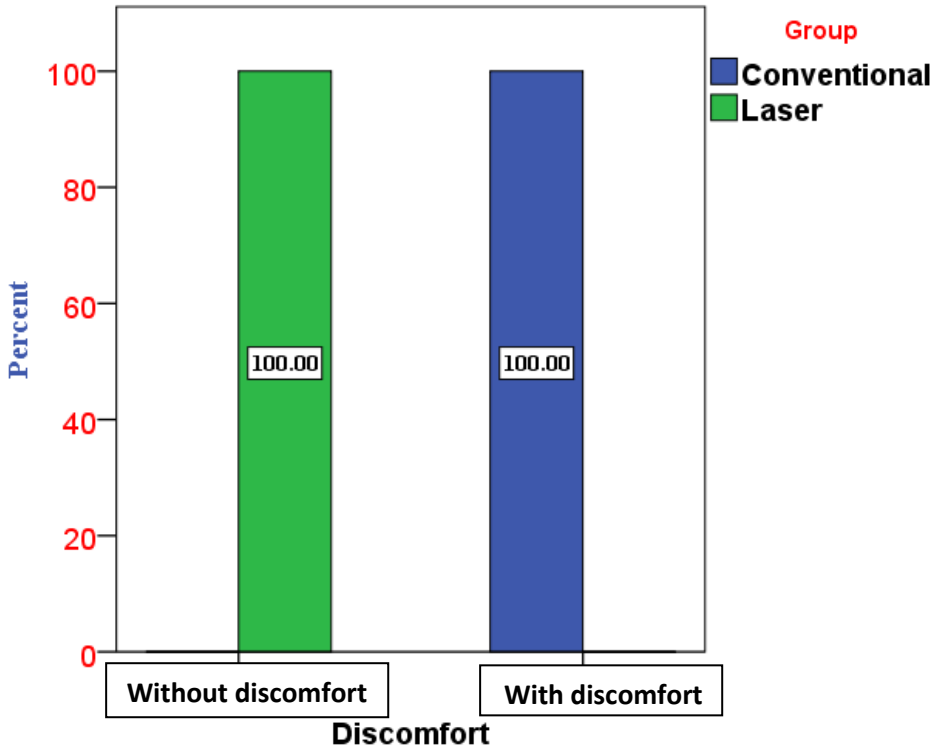

Figure 3-5: Distribution of comfort among groups

3.1.3 Duration of the procedure

The duration of the procedures was recorded for each patient during the procedure with (3-7 minutes) for laser procedure and (7-15 minutes) for conventional. A highly significant difference was observed in duration among laser and conventional groups as shown in table (3-5). The median of duration can be seen in fig. (3-6).

Table 3-5: Descriptive and statistical test of duration among groups

Statistics	Group	
	Conventional	Laser
Minimum	7.000	3.000
Maximum	15.000	7.000
Mean	12.444	5.389
Std. Deviation	2.382	1.037
Median	13.000	5.000
Shapiro Wilk	.879	.025
Shapiro p-value	.878	.024
Mean rank	27.42	9.58
Z	5.134	
P-value	0.000 (HS)	

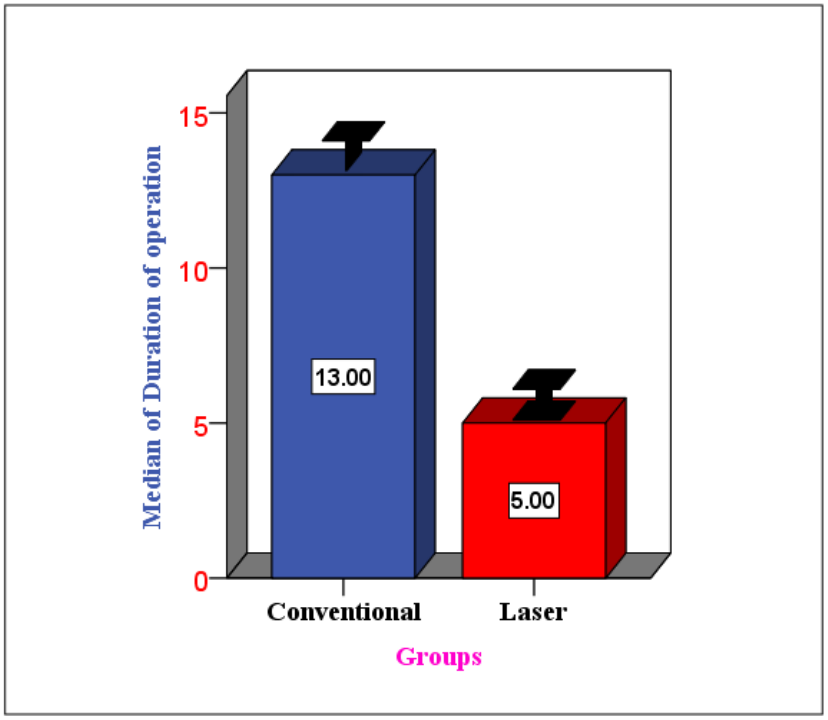

Figure 3-6: Median of duration among groups

3.1.4 Bleeding

Bleeding was evaluated intraoperatively. Few patients were developed minimum and self-limiting bleeding in laser site, while for conventional method an evident bleeding was observed that requires a firm pressure along with hemostatic solution. A highly significant association in bleeding was observed between laser and conventional groups as shown in table (3-7). Table (3-6) shows the development of bleeding for conventional as well as laser group. Fig. (3-7) shows the distribution of bleeding among groups.

Table 3-6: Development of bleeding for both groups

Technique	Bleeding score				
	None	Self-limiting	Require pressure	Require coagulation + pressure	Require ligation or hemoclip
Conventional	0	0	0	18	0
Laser	15 over 18	3 over 18	0	0	0

Table 3-7: Association between distribution of bleeding among groups

		Group		Fisher exact	P-value
		Laser	Conventional		
No bleeding	NO.	15	0	41.841	0.000 HS
	% within Group	83.33	.00		
	% of Total	41.67	.00		
Self-limiting	NO.	3	0		
	% within Group	16.67	.00		
	% of Total	8.33	.00		
Requiring coagulation+ pressure	NO.	0	18		
	% within Group	.00	100.00		
	% of Total	.00	50.00		

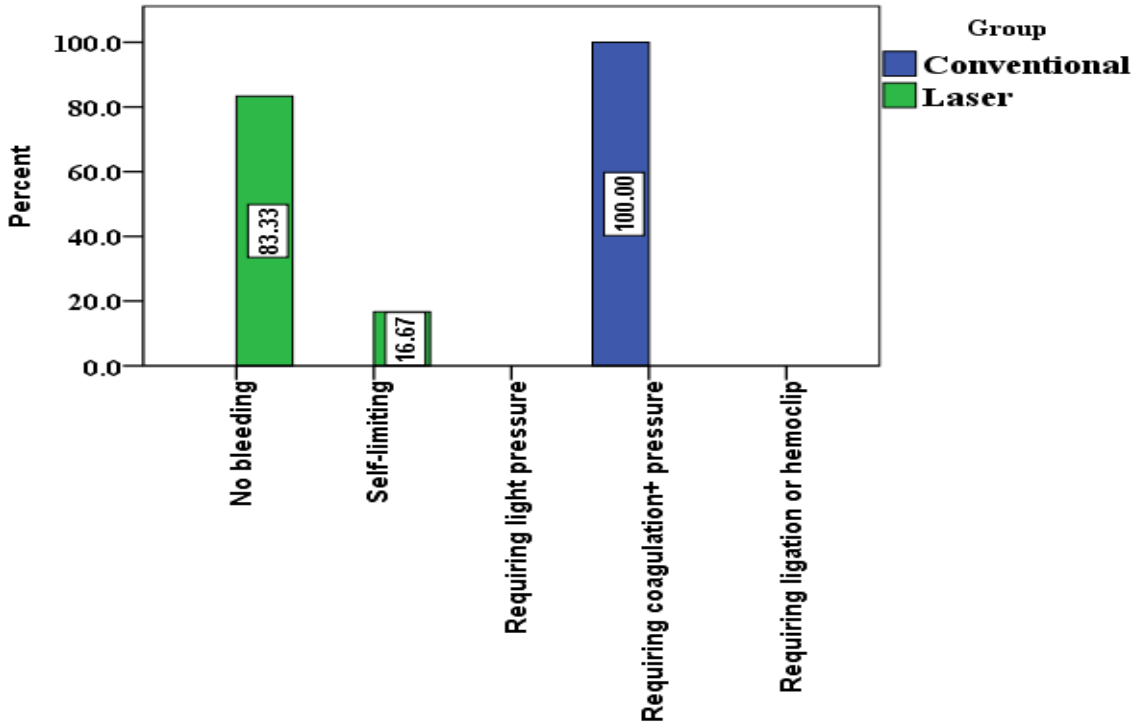

Figure 3-7: Distribution of bleeding among groups

3.1.5 Healing

Healing was evaluated after, 3 days, 1 week and 1 month postoperatively. a highly significant change in healing can be seen within each group with time, but without significant difference within each period of time between laser and conventional group as shown in table (3-9). Table (3-8) shows the development of healing postoperatively. The median of healing scores can be seen in fig. (3-8).

Table 3-8: Development of healing using healing index

TECH. / Days	Conventional					Laser				
Scale	Very poor	Poor	Good	Very good	Excellent	Very poor	Poor	Good	Very good	Excellent
3 days	0	10 over 18	8 over 18	0	0	0	4 over 18	11 over 18	3 over 18	0
7 days	0	0	4 over 18	10 over 18	4 over 18	0	1 Over 18	1 over 18	10 over 18	6 over 18
1 month	0	0	0	0	18	0	0	0	0	18

Table 3-9: Descriptive and statistical test of healing

Group	Statistics	3days	1week	1month	Quade test	Sig.	Multiple comparisons P-value		
Conventional	Mean	1.44	3.00	4.00	62.36	0.000 HS	3 days	1 week	**0.000**
	SD	.51	.69	.00			3 days	1 month	**0.000**
	Median	1.00	3.00	4.00			1 week	1 month	**0.000**
	Minimum	1.00	2.00	4.00					
	Maximum	2.00	4.00	4.00					
	Weighted Mid ranks	-171	9	162					
Laser	Mean	1.94	3.17	4.00	51.84	0.000	3 days	1 week	**0.000**
	SD	.64	.79	.00			3 days	1 month	**0.000**
	Median	2.00	3.00	4.00			1 week	1 month	**0.000**
	Minimum	1.00	1.00	4.00					
	Maximum	3.00	4.00	4.00					
	Weighted Mid ranks	-162.75	8.25	154.5					
Two sample KS	Z	1	0.333	0					
	P-value	0.270	1	1					

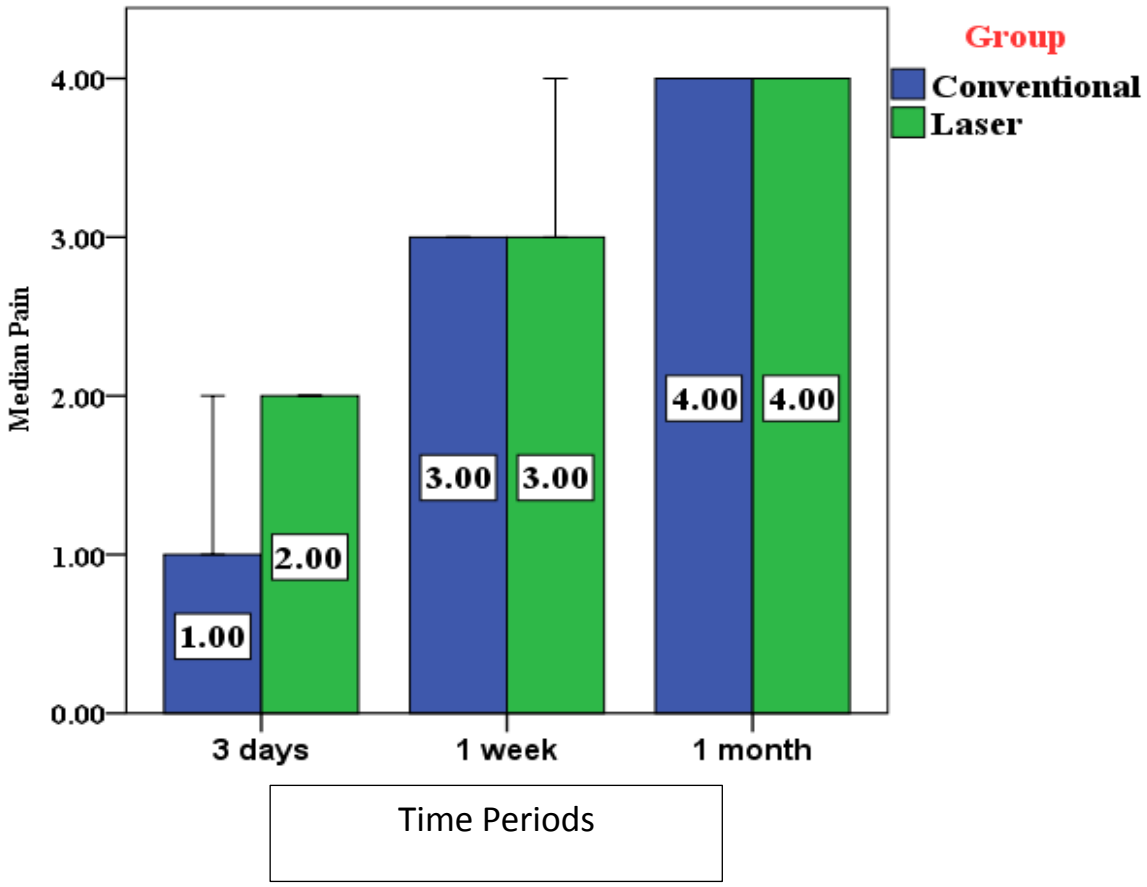

Figure 3-8: Median of healing score

3.1.6 Functions

Functions like smiling, eating and speaking where evaluated by the patients after day 1, 3 days and 1 week postoperatively. Most of the patients were recorded some difficulties in performing these functions in the site which was treated using conventional method, also salty and acidic food causes a discomfort and mild pain during eating, while in laser group none of that were happened. A highly significant change of limited function can be observed among conventional group within period of time while in laser group no significant change was observed as shown in table (3-11). Table (3-10) shows the development of limited functions for laser as well as conventional site postoperatively. Fig (3-9) and (3-10) shows the distribution of limited function for conventional as well as for laser groups.

Table 3-10: Development of limited functions for both groups

Tech. / Day	Conventional				Laser			
	Limited function		Normal Function		Limited function		Normal function	
1ST day	14 over 18	(77.77%)	4 over 18	(22.22%)	1 over 18	(5.55%)	17over 18	(94.44%)
3rd day	5 over 18	(27.77%)	13 over 18	(72.22%)	0 over 18	(0%)	18	(100%)

Table 3-11: Association and change of limited function between groups and time

Group	Status	NO & %	Period		Mc Nemar's test
			1day	3days	
Conventional	With Limited functions	NO.	14	5	0.004 HS
		% within Group	77.78	27.78	
		% T	38.89	13.89	
	Without Limited functions	NO.	4	13	
		% within Group	22.22	72.22	
		% T	11.11	36.11	
Laser	With Limited functions	NO.	1	0	1.00 NS
		% within Group	5.56	.00	
		% T	2.78	.00	
	Without Limited functions	NO.	17	18	
		% within Group	94.44	100.00	
		% T	47.22	50.00	

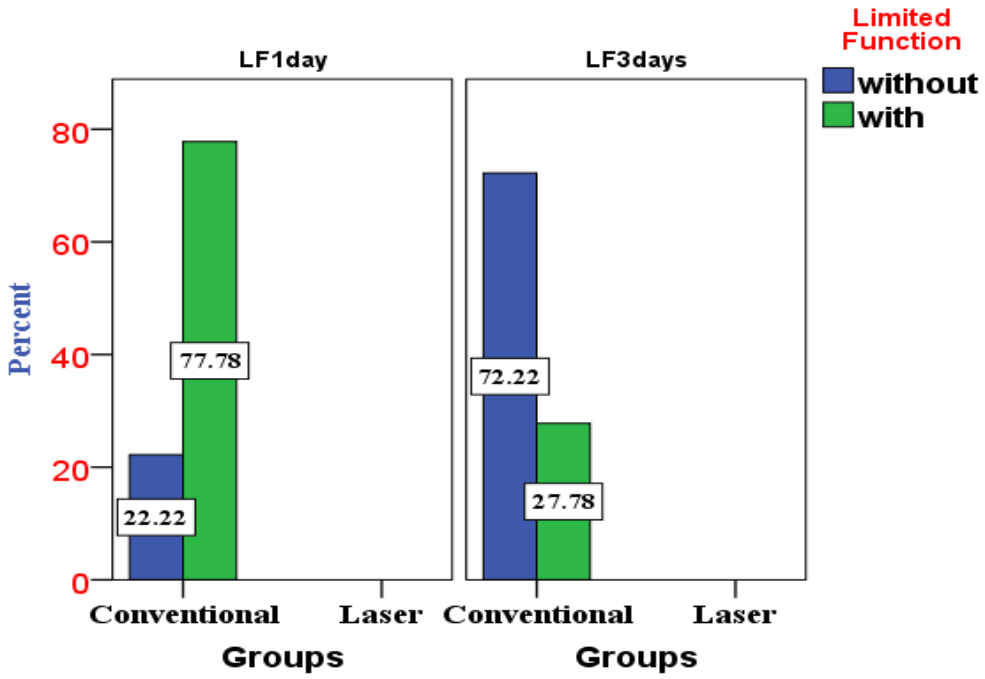

Figure 3-9: Distribution of limited function for conventional method.

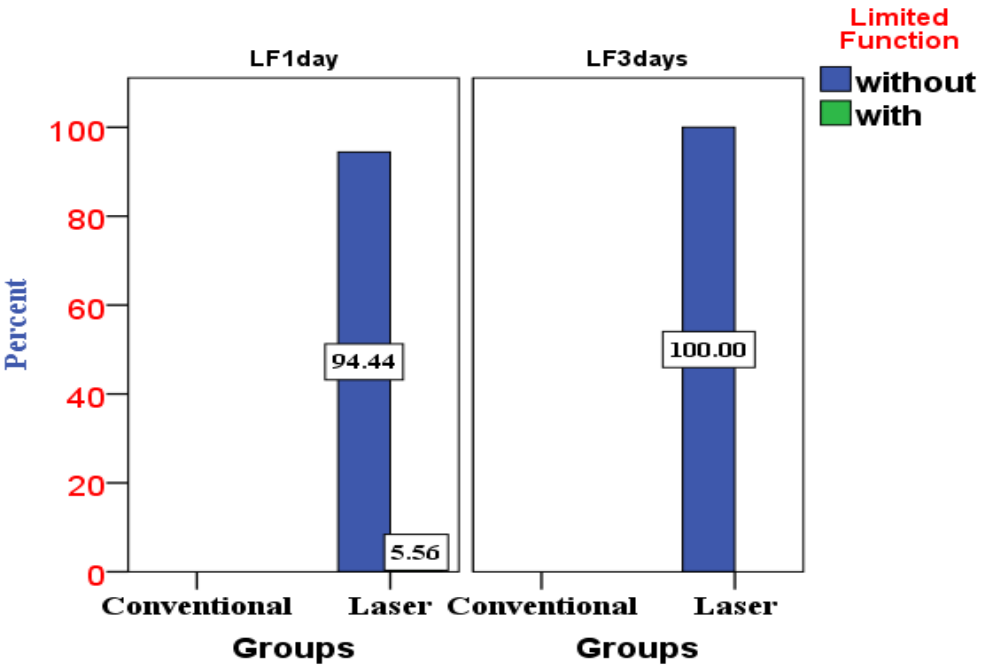

Figure 3-10: Distribution of limited function for laser method

3.1.7 Re-pigmentation (recurrence of pigmentation)

Re-pigmentation was evaluated after 1 month and 6 months postoperatively. A highly significant change was observed in re-pigmentation among each group within time period but without significant difference between them within this time period as shown in table (3-14). Table (3-12) and (3-13): shows the development of the intensity of recurrence of pigmentations for the period of 1 and 6 months postoperatively. The median of re-pigmentation scores can be seen in fig. (3-11)

Table 3-12: Development of recurrence after 1 month

Surgical site	**Re-pigmentation score (Slight, moderate, heavy)**			
	No recurrence	**Slight**	**Moderate**	**Heavy**
Conventional site	15 over 18	3 over 18	0	0
Laser site	16 over 18	2 over 18	0	0

Table 3-13: Development of recurrence after 6 months

Surgical site	**Re-pigmentation score (Slight, moderate, heavy)**			
	No recurrence	**Slight**	**Moderate**	**Heavy**
Conventional site	9 over 18	5 over 18	4 over 18	0
Laser site	9 over 18	7 over 18	2 over 18	0

Table 3-14: Descriptive and statistical test of re-pigmentation score

Group	Statistics	1 month	6 months	Marginal homogeneity test	Sig.
Conventional	Mean	.167	.722	2.887	0.004 HS
	SD	.383	.826		
	Median	.000	.500		
	Minimum	.000	.000		
	Maximum	1.000	2.000		
Laser	Mean	.111	.611	3.00	0.003 HS
	SD	.323	.698		
	Median	.000	.500		
	Minimum	.000	.000		
	Maximum	1.000	2.000		
Two sample KS	Z	0.167	0.333		
	P-value	1.00 (NS)	1.000(NS)		

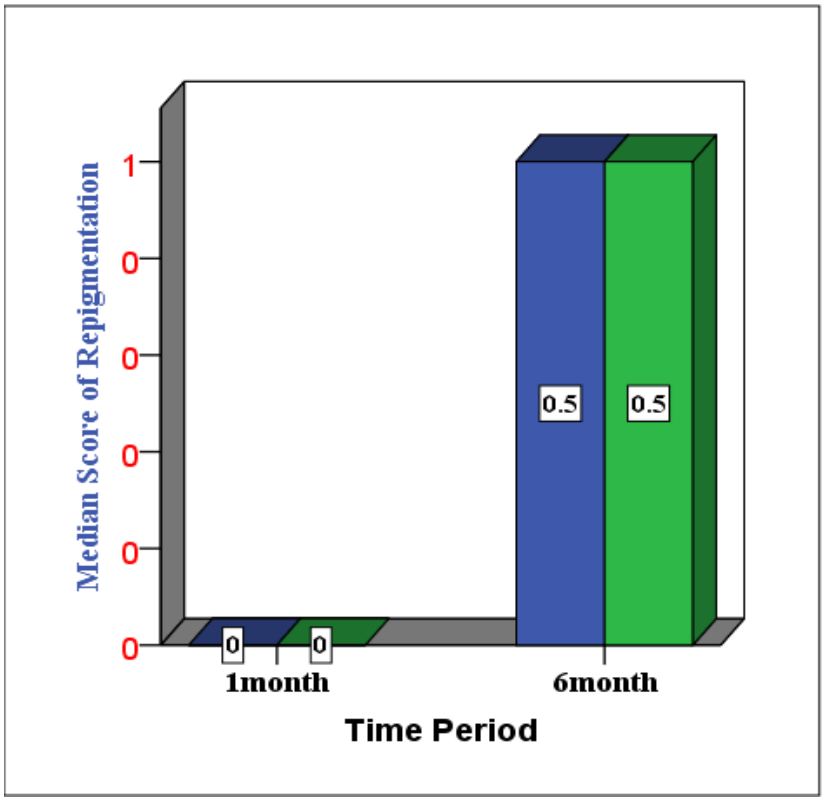

Figure 3-11: Median of re-pigmentation score

3.1.8 Medications

Medications were prescribed for each patient when necessary (if they encounter a severe and intolerable pain). For conventional group only 4 over 18 patients were used medications after 1 day postoperatively, while no medications were used in laser group. After 3 days postoperatively, no medications were used among both groups. No significant association was observed for medication user among groups as shown in table (3-15). Fig. (3-12) shows the distribution of medications use among groups.

Table 3-15: Association between medication used and groups

Technique	Medications used		No medications		F.E.P.T	P-value
	NO.	%	NO.	%		
Conventional	4	(22.22%)	14	(77.78%)	4.500	0.104
Laser	0	(0%)	18	(100%)		NS

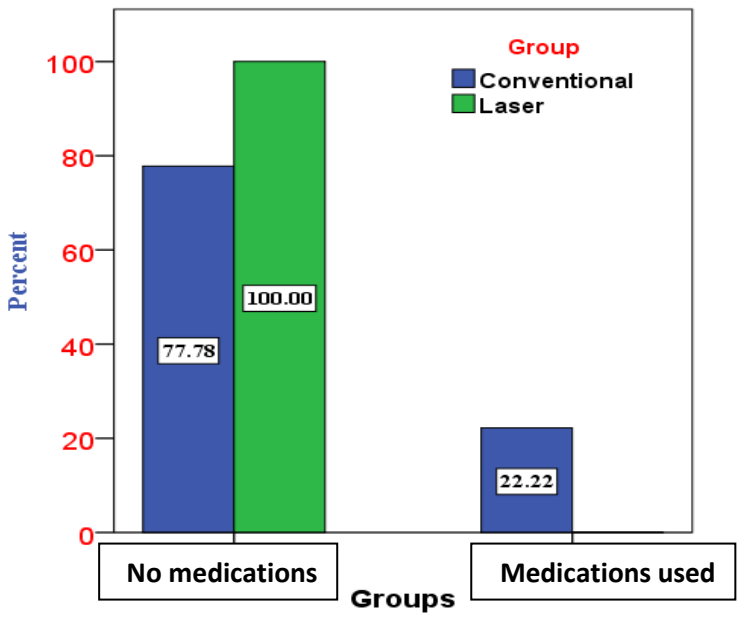

Figure 3-12: Distribution of medications used among groups

3.1.9 Discussion

Gingival hyperpigmentation is a common problem that doesn't considered as a disease, but the patients seeks to manage this problem for aesthetic reasons. A lot of depigmentation techniques has been developed in order to solve this problem. The selection of a technique for depigmentation is mainly depend on affordability of the patient, clinical experience and preferences. Diode laser is preferred among many methods for depigmentation due to minimal damage to the underlying bone and connective tissue., thus the pigmented epithelium layer was removed easily and softly [12]. Diode laser also possess a lot of advantages which include: hemostasis, less pain and discomfort postoperatively, minimal swelling, sterilization effect and Patients satisfaction [111]. Diode laser can be used in depigmentation procedures in two ways:

1- Absorption of diode laser by melanin pigment which result in melanin breakdown and subsequent removal by phagocytosis.

2- De-epithelization technique, depending on temperature elevation and vaporization of cellular water content of epithelium layer (achieved by initiation of fiber tip).

In this study, the de-epithelization technique was used because the goal was to remove the melanocyte cells. The mechanism of de-epithelization in depigmentation is that the tip was initiated using tip initiation kit, this procedure causes the laser light to be absorbed by this coat at the end of laser tip to produce a concentrated heat effect at the end of the tip. So, according to laser-tissue interactions principle this heat will cause vaporization of the cellular water content of epithelium layer (epithelium layer is cellular in nature while the underlying connective

tissues about 60% fibrous in nature [52]) without causing damage to the underlying connective tissues due to low water content there.

The simplicity of conventional method and its low cost makes it preferred by the patients, though it possesses many disadvantages which include:

1) The far posterior areas of the gingiva (especially upper gingiva) were difficult to reach when using the conventional methods; thus, the posterior pigmentations were difficult to remove.

2) Care must be taken to avoid damage to underlying connective tissues and hitting tooth structures.

3) Bleeding from the surgical site.

4) Discomfort during the procedure was reported by the patients due to the sound and vibration of the bur, water leverage, presence of suction tube and the duration of the procedure.

5) Difficulties in controlling the depth of de-epithelization during the surgery.

For pain and functions, the majority of the patients were recorded with pain that ranged from mild to severe pain for the 1st 3 days of the procedure as well as limited functions for conventional site. The reason is due to exposed nerve endings which are stimulated directly by any external factors. while for laser site, a few patients were recorded with a mild pain as well as limited functions. The reason for that is due to the formation of protein coagulum at the wound surface which acts as a biologic dressing by sealing the sensory nerve endings [112]. These results were in agree with the results reported by (Sathyanarayanan, C.

and Iyer, V.H., 2014) [113] who compared between the conventional bur method and 940 diode laser in management of hyperpigmentation.

Bleeding was observed intra-operatively in the left quadrant (conventional site) for all patients and it require coagulation as well as pressure to be stopped. While few patients were developed minimum and self-limiting bleeding in laser site. The reason is due to denaturation of protein and collagen that present in blood vessel's walls by the elevation of temperature resulting in vasoconstriction in laser site [114]. These results were in agree with result obtained by (El Shenawy H. et.al 2015) [115] who used diode laser for depigmentation.

Healing with laser after 3 days was slightly better than that of conventional. Diode laser has the ability to remove the outer epithelium layer cleanly without damage to the underlying connective tissues, also the sterile effect as well as absence of inflammatory reactions were observed in wound area after using laser [112]. After 1 week to 1 month the healing was the same for both sites. These results were in agree with result obtained by (Mani A. et.al 2009) [112] who used surgical blade, diamond bur and diode laser in depigmentation.

Re-pigmentation (reappearance of pigmentation after treatment) have been noticed in both sites after 6 months post-operatively which is ranged between slight to moderate recurrence. Some of these recurrences were observed in dark-skinned patients which are suspected of having abnormal melanocytes activity. Other recurrences were observed in some patients in which their pigmentations were not removed completely during the surgery (due to inaccurate depigmentation procedure). The cause of re-pigmentation is the melanocytes' nature which have a reproductive self-maintaining system [116]. However, it was believed that

regimentation can occur due to migration of active melanocytes from the adjacent pigmented tissues to the treated site [83]. Some studies compared diode with bur methods for re-pigmentation and found that there was no recurrence for both sites (Murthy MB. et.al 2012) [117], while other studies (Sathyanarayanan, C. and Iyer, V.H., 2014) [113] shows a slight recurrence in pigmentation for laser site compared to conventional site.

3.2 Conclusion

1. diode laser is considered as an effective in pain, discomfort, functions, bleeding and duration of the surgery compared to conventional method, while for healing and re-pigmentation both laser and conventional method has the same results after depigmentation.

2.Patient satisfaction about the laser treatment as there was no postoperative complications.

3.Repigmentation of gingiva can occur after the depigmentation depending on the causative factor, Ethnic background, habit and accuracy of the depigmentation procedure.

3.3 Suggestion for future work

1. A comparison between 940 nm diode laser and other types of lasers in management of gingival hyperpigmentation.

2. The reproductive ability of melanocytes after depigmentation and how to eliminate the re-pigmentation.

3. Low level laser therapy using 940 nm diode laser in management of hyperpigmentation.

4. A study with Longer follow up to see how many it takes for laser pigmentation to reoccur completely once again.

5. Histopathological studies for pigmented tissues before and after the depigmentation procedure (before the procedure, immediately after the procedure, after 6 months, after 1 year and after 4 year)

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Appendices

Appendix I

(Patient's case sheet)

Case sheet

Patient's name: **Occupation:**

Age: **phone number:**

Sex:

Chief complaint:

Bleeding	☐	Gingival pigmentation	☐
Unpleasant teste	☐	Pathological mobility	☐
Halitosis	☐	Migration of teeth	☐
Dry mouth	☐	Hypersensitivity	☐
Pain	☐		

Others .....

HPI .....

Past dental history

Visit to dentist. Regular.....Irregular.....

Tooth brushing yes..... No..... Frequency.....

Previous periodontal treatment.....

Habits

Bruxism ☐ Clenching ☐

Smoking ☐

Pregnancy .....

Medical history.....

systemic diseases:

Acquired or congenital heart disease: .....

Blood pressure disturbances: .....

Diabetic mellitus: .....

Infectious diseases: .....

Epilepsy: ……..

Organ transplantation: ……..

Others ……

Gingival pigmentation index

Side	Score (0)	Score (1)	Score (2)	Score (3)
Left side				
Right side				

- Score 0: Absence of pigmentation
- Score 1: Spots of brown to black color or pigments.
- Score 2: Brown to black patches but not diffuse pigmentation
- Score 3: Diffuse brown to black pigmentation, marginal, and attached

اسم المريض:

التأريخ:

التوقيع:

Appendix II

(Evaluation case sheet)

Evaluation case sheet

Patient's name: ..... **Occupation:** .....

Age: ..... **Phone number:** .....

Sex: .....

1. pain

Surgical site	**Pain using (VAS) 0----------5----------10** **0= no pain 5= moderate pain 10=sever pain**		
	1st day	**3 days**	**1 week**
Conventional site	.....	.....	.....
Laser site	.....	.....	.....

2. Bleeding

Surgical site	**Bleeding**	**No bleeding**
Conventional site	.....	.....
Laser site	.....	.....

3. Duration of procedure

Techniques	**Duration (minutes)**
Conventional method	.....
Laser method	.....

4. Functions

Surgical site	**Functions (+, -)** **+= limited functions -= normal functions**		
	1st day	**3 days**	**1 week**
Conventional site	.....	.....	.....
Laser site	.....	.....	.....

5. Healing

Surgical site	Healing using healing index score (0,1,2,3,4) 0= very poor 1=poor 2= good 3= very good 4= excellent		
	3 days	1 week	1 month
Conventional site	.....	.....	.....
Laser site	.....	.....	.....

6. Re-pigmentation

Surgical site	Re-pigmentation score (Slight, moderate, heavy)	
	1 month	6 months
Conventional site	.....	.....
Laser site	.....	.....

7. Discomfort

Techniques	Comfortable	Uncomfortable
Conventional method	.....	.....
Laser method	.....	.....

8. Medications

Surgical site	Medications used	No medications
Conventional	.....	.....
Laser	.....	.....

Appendix III

(Patient's questionnaire)

استمارة المريض

اسم المريض ..... رقم الهاتف .....

الجنس ..... العمر ..... العنوان .....

المهنه .....

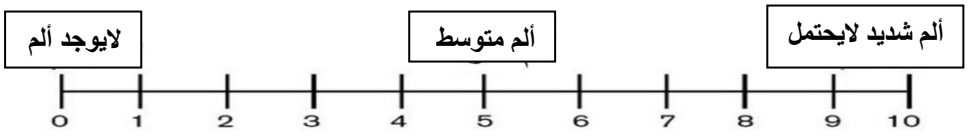
كيف وجدت العلاج بااستخدام الطريقة العادية (بأستخدام البير الجراحي)؟

.....
.....
.....

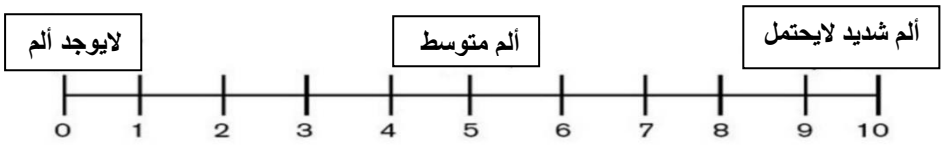
كيف وجدت العلاج باستخدام الليزر؟

.....
.....
.....

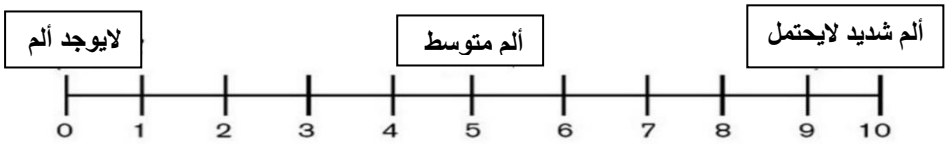
بعد اليوم الاول من العملية مباشرة هل شعرت بألم بسبب ااستخدام الطريقة العاديه .....ام باستخدام الليزر ..... واذا كان نعم فعلى مقياس (0-10) حدد نسبة المك



بعد مرور ثلاثة ايام من اجراء العملية هل يوجد الم واذا كان نعم هل هو نتيجة استخدام الطريقة العادية
.....ام طريقة الليزر..... .حدد نسبة المك



بعد مرور سبعة ايام من العملية هل يوجد ألم واذا كان نعم هل هو نتيجة استخدام الطريقة العادية
.....ام طريقة الليزر..... حدد نسبة المك



هل استطعت اداء مهامك الاعتيادية كاملة كالتكلم والاكل بصوره اعتيادية بعد اليوم الاول من العملية مباشره؟

.....
.....

بعد ثلاثة ايام؟

.....
.....

بعد اسبوع؟

.....
.....

برأيك ماهي افضل طريقة لعلاج تصبغ اللثة هل هي بااستخدام الطريقة العادية (طريقة البير الجراحي) ام باستخدام الليزر ولماذا؟

.....
.....
.....

الملاحظات ان وجدت

.....
.....
.....
.....

Appendix IV

(Patient's consent)

موافقة المريض على اجراء العملية

(patient's consent)

اني الموقع ادناه اوافق على اجراء عملية ازالة تصبغ اللثه من قبل الدكتور هاني محمد باجي وهو معفي من اي اخطاء طبيه تترتب خلال او بعد العملية ولاجله وقعت.

اسم المريض:

التاريخ:

التوقيع:

وزارة التعليم العالي والبحث العلمي

جامعة بغداد

معهد الليزر للدراسات العليا

علاج تصبغات اللثة الفسيولوجية بأستخدام ليزر الدايود ٩٤٠ نانومتر (دراسة مقارنه في وسط حيوي)

رسالة مقدمة الى

معهد الليزر للدراسات العليا /جامعة بغداد /لاستكمال متطلبات نيل شهادة ماجستير علوم في الليزر/ طب الاسنان

من قبل

هاني محمد باجي

بكالوريوس طب وجراحة الفم والاسنان

بإشراف

الأستاذ المساعد الدكتور مهدي علي سكر

١٤٣٩ هـ **٢٠١٨ م**

الخلاصة

الهدف من الدراسة: للمقارنة بين ٩٤٠ نانومتر ليزر الدايود وطريقة البير التقليدية في ازالة تصبغات اللثة.

المواد والطرق: تم اختيار ثمانية عشر مريضا تتراوح اعمارهم بين ١٢-٣٧ سنة. وكانت اللثة العليا فقط هي اللتي تم علاجها في هذا الدراسة. تم التعامل مع النصف الأيمن العلوي من اللثة بواسطة الليزر بينما تم التعامل مع النصف الأيسر العلوي باستخدام الطريقة التقليدية. تم إعادة تقييم المرضى بعد ٣ أيام، ٧ أيام، ١ شهر وبعد ٦ أشهر بعد العملية. تم تقييم الألم، الازعاج، والشفاء، الفعاليات ورجوع التصبغات كل زيارة، كما تم تقييم النزيف ومدة العملية الجراحية اثناء العملية. تم أستخدام ليزر الدايود (٩٤٠ نانومتر) مع ليف كنظام توصيل في هذه الدراسه.اعدادات الليزر اثناء العملية كانت الطاقة ١,٥ واط في وضع مستمر مع طرف ليف (٤٠٠ ميكرون) يوضع ملامس للانسجة.

النتائج: أظهرت النتائج وجود فروقات معنوية في الألم، الازعاج، والوظائف، والنزيف، ومدة العملية، في حين لم يلاحظ وجود اختلافات كبيرة في الشفاء ورجوع التصبغات بين المجموعات.

الاستنتاج: تبين من الدراسة ان الدايود ليزر يعتبر فعال من ناحية الالم، الازعاج، الوظائف، النزف ومدة العملية مقارنة بالطريقة التقليدية، اما من ناحية الشفاء ورجوع التصبغات كل من طريقة الليزر والطريقة التقليدية يمتلكان نفس النتائج بعد عملية ازالة التصبغات.