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Rejuvenation of Facial Skin Using Fractional Er:YAG Laser

A Dissertation Submitted to the Institute of Laser for Postgraduate Studies – University of Baghdad in Partial Fulfillment of the Requirement for the Degree of Higher Diploma in Laser in Medicine/Plastic Surgery

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بِسْمِ اللَّـهِ الرَّحْمَـٰنِ الرَّحِيمِ

وَقَضَىٰ رَبُّكَ أَلَّا تَعْبُدُوا إِلَّا إِيَّاهُ وَبِالْوَالِدَيْنِ إِحْسَانًا ۚ إِمَّا يَبْلُغَنَّ عِندَكَ الْكِبَرَ أَحَدُهُمَا أَوْ
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Dedication

To the memory of my father and my mother who always believed in me.

ABSTRACT

Background: Fractional Erb:YAG laser resurfacing is increasingly used for treating rhytides and photo aged skin because of its favorable benefit-risk ratio. The multi-stacking and variable pulse width technology opined a wide horizon of rejuvenation treatments using this type of laser.

Objective: Is to evaluate the efficacy and safety of the use of fractional 2940 nm Er:YAG laser in facial skin rejuvenation.

Materials and methods: 12 female patients with mean age 48.3 years and multiple degrees of aging signs and solar skin damages, were treated with 2 sessions, one month apart by fractional Erb: YAG laser, each session consisted of 2 steps, the first step employed the use of the multi stack ablative fractional mode and the fractional long pulsed non-ablative mode settings were used in the second step. The results were assessed 4-8weeks after the last session by using the wrinkles assessment scale improvement, the improvement in the degree of dyschromia and keratosis, the degree of patients' satisfaction and rate of complications.

Results: The mean improvement in Wrinkles assessment scale was very satisfying**.** The improvement in keratosis was good to excellent in 66.7% of patients compared to 33.3% of patients who were mildly to moderately improved. Dyschromia improvement, 50% of the patients had good to excellent results versus 50% who had mild to moderate improvement. 75% of patients were well satisfied, 16.6% were moderately satisfied and 8.3% were unsatisfied. Total incidence of complications was 16.6%, where 1 patient had herpes infection and a second patient had milia.

Conclusion: the use of Erb:YAG laser in fractional ablative and fractional long pulse non ablative modes for facial rejuvenation is an effective, safe, with short down time and low complication rate.

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LIST OF ABBRIVIATIONS

ANSI	American National Standards Institute
C	Cheek
CF	Crow's feet
cm	Centimeter
cm^2	Squired centimeter
CO2	Carbon Dioxide
Erb:YAG	Erbium: Yttrium-Aluminum-Garnet
Erb:YSGG	Erbium: yttrium-scandium-gallium-garnet
FH	Forehead
Hz	Hertz
J	Joule
mj	Milli joule
mm	Millimeter
ms	Millisecond
mw	milliwatt
nm	nanometer
PO	Perioral
Sec.	Second
w	watt
WSA	Wrinkles Assessment Scale
µs	Microsecond

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INTRODUCTION AND BASIC CONCEPTS

CHAPTER ONE

INTRODUCTION AND BASIC CONCEPTS

1. Introduction:

Facial aging: reflects the dynamic, cumulative effects of time on the skin, soft tissues, and deep structural components of the face, and is a complex synergy of skin textural changes and loss of facial volume. Many of the facial manifestations of aging reflect the combined effects of gravity, progressive bone resorption, decreased tissue elasticity, and redistribution of subcutaneous fullness [1, 2]

Skin aging: As the most voluminous organ of the body that is exposed to the outer environment, the skin suffers from both intrinsic and extrinsic aging factors. Skin aging is characterized by features such as wrinkling, loss of elasticity, laxity, discoloration and rough-textured appearance [3]. This aging process is accompanied with phenotypic changes in cutaneous cells as well as structural and functional changes in extracellular matrix components such as collagens and elastin [4, 5].

1.1. Histology and function of the skin.

1.1.1. Histology.

Skin is part of the integumentary system and considered to be the largest organ of the human body. There are three main layers of skin: the epidermis, the dermis, and the hypodermis (subcutaneous fat). Skin appendages such as sweat glands, hair follicles, and sebaceous glands [6.7]. The first and outermost layer of skin is the epidermis. The epidermis is a stratified squamous epithelium that contains four to five layers depending on its location:

1-Stratum Basalis (Basal cell layer): This layer is deepest and closest to the dermis. It is mitotically active and contains melanocytes, a single row of keratinocytes, and stem cells. Melanocytes are the cell type responsible for producing melanin, a substance that gives our skin its color. Keratinocytes from this layer evolve and mature as they travel outward/upward to create the remaining layers [6, 7, and 8].

2-Stratum Spinosum (prickle cell layer): This layer compromises most of the epidermis and contains several layers of cells connected by desmosomes. These desmosomes allow cells to remain tightly bound to one another and resemble "spines" architecturally.

3-Stratum Granulosum (granular cell layer): This layer contains several layers of cells that contain lipid-rich granules. In this layer, cells begin to lose their nuclei, as they move away from the nutrients located in the deeper tissue [6, 7, and 8].

4-Stratum Lucidum: This layer only exists in the thick skin of soles and palms and consists of mostly mortalized cells [6, 7, and 8].

5-Stratum Corneum (keratin layer): This keratinized layer serves as a protective overcoat and is the outermost layer of the epidermis. Due to keratinization and lipid content, this layer allows for the regulation of water loss by preventing internal fluid evaporation [6, 7, and 8].

Deep to the epidermis lies the dermis. It is a thick layer of connective tissue consisting of collagen and elastin which allows for skin's strength and flexibility, respectively. The dermis also contains nerve endings, blood vessels, and adnexal structures such as hair shafts, sweat glands, and sebaceous glands. The apical layer of dermis folds to form papillae that extend into the epidermis like tiny finger-like projections and is referred to as the papillary dermis, while the lower layer of the dermis is referred to as the reticular dermis.

The hypodermis is the third and deepest layer consisting mainly of adipose tissue (figure.1.1).

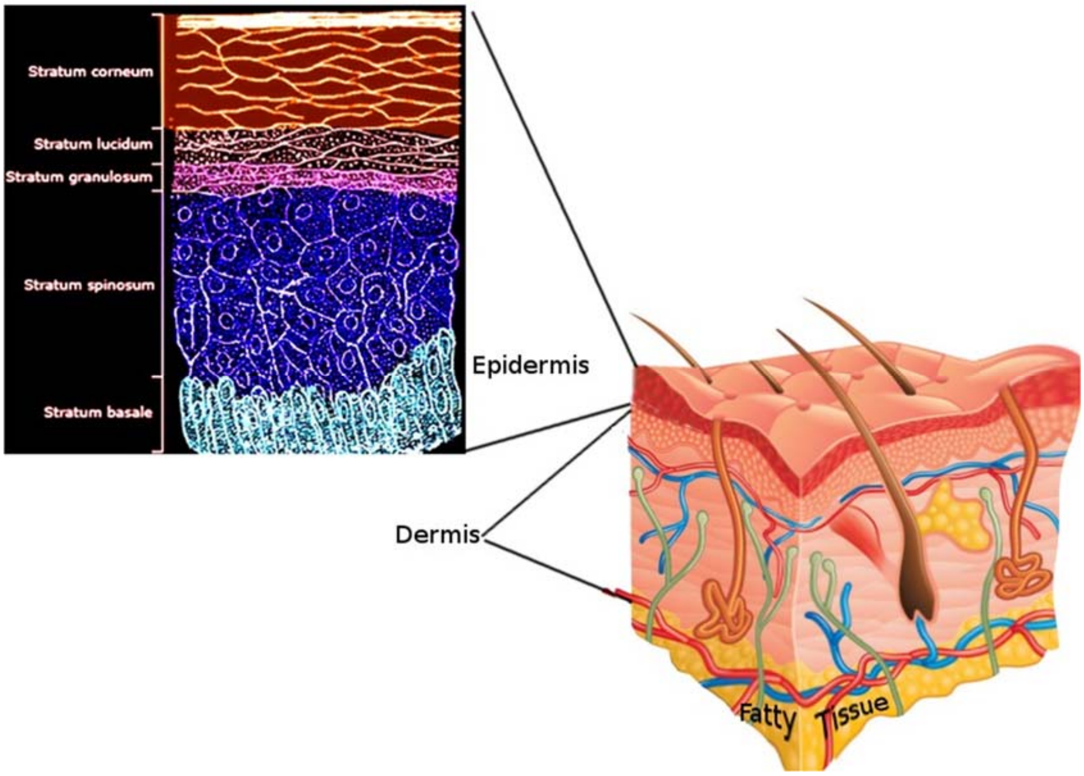


Figure 1.1 Layers of the skin[8]

1.1.2. Function.

Sensation: The skin contains many types of different receptors that sense pain, temperature, pressure, and touch.

Thermoregulation: Hair and sweat glands aid in the regulation of body temperature to maintain homeostasis.

Protection: The skin serves as the barrier between the inside and outside of the body against infection, chemical stress, thermal stress, and UV light.

Metabolism: Adipose tissue in the hypodermis is vital in the production of Vitamin D and lipid storage [7, 8, and 9].

1.3. Pathophysiology of skin aging.

1.3.1. Changes in Skin Aging

Exposed directly to the air, skin is not only subject to intrinsic aging but also superimposed by extrinsic aging. These aging processes are accompanied by phenotypic changes in cutaneous cells as well as structural and functional changes in extracellular matrix components such as collagens, elastin, and proteoglycans that are required to provide tensile strength, elasticity, and hydration to the skin, respectively [3, 10].

1.3.1.1. Changes in Intrinsic Aging

Intrinsic skin aging is a process of chronologically physiological change. Aging of photo protected areas for example, the inner side of the upper arm, is mainly due to intrinsic genetic or metabolic factors, whereas exposed skin areas are additionally influenced by extrinsic factors, especially solar UV radiation

[11]. For the intrinsically aged skin, the most remarkable histological changes occur within the basal cell layer. Research finds that as a person ages, proliferation of cells in the basal layer reduces. The epidermis then becomes thinner, and the contact surface area between dermis and epidermis decreases, resulting in a smaller exchange surface for nutrition supply to the epidermis and further weakened ability of basal cell proliferation [12, 13]. This process of decreased proliferative ability of cells including keratinocytes, fibroblasts, and melanocytes is called cellular senescence. In skin samples from human donors of different ages, there was an age-dependent increase in the expression of senescence marker β-galactosidase in dermal fibroblasts and epidermal keratinocytes, indicating that aged skin contains more senescent cells [14].

In addition, the dermis of photo protected aged skin shows not only fewer mast cells and fibroblasts than photo protected young skin but also rarefied collagen fibers and elastic fibers [15]. It is reported that the production of type I procollagen in intrinsically aged human skin is reduced likely because of down-regulation of the TGF-β/Smad signaling and its downstream connective tissue growth factor, which is regarded as a regulator of collagen expression [16]. Moreover, evidence supports that in intrinsically aged skin, not only fibrous extracellular matrix components including elastin, fibrillin, and collagens but also oligosaccharide are degenerated, which in turn influences the ability of skin to retain bound water [17].

1.3.1.2. Changes in Extrinsic Aging

The most important extrinsic factors that influence skin aging are **UV radiation, smoking and nicotine** and other life style factors. As early as 1969, it was proposed that besides intrinsic factors, sun exposure also leads to skin aging [18]. Exposure to UV radiation is the primary factor of extrinsic skin aging; it accounts for about 80% of facial aging [19]. In contrast to the thinner epidermis in intrinsically aged skin, UV-radiated epidermis thickens [20]. As the outermost layer of the epidermis, stratum corneum is mostly affected and thickens because of failure of degradation of corneocyte desmosomes. The expression of differentiation marker involucrin in stratum corneum is increased, which is in accord with the fact that the differentiation process of epidermal keratinocytes is impaired by UV irradiation. In basal cells, the expression of cell-surface protein β1-integrin, which interacts with extracellular matrix proteins and is regarded as one of the epidermal stem cell markers, is greatly reduced, indicating that proliferation in the aged basal keratinocytes is also impaired [21,22].

The expression of type VII collagen in keratinocytes decreased in UV-radiated skin areas. Type VII collagen is the anchoring fibrils at the dermal–epidermal junction. The decrease in its production contributes to wrinkles due to the weakened connection between dermis and epidermis [23]. Studies have found that collagen type I diminishes in photo-aged skin [24, 25] due to increased collagen degradation [26]. Various matrix metalloproteinases (MMPs), serine proteases, and other proteases participate in this degradation activity [22, 27, and 28] .For photoaged skin, a striking characteristic is the accumulation of abnormal elastic tissue deep in the dermis [29], a pathologic phenotype named solar elastosis. UV-irradiation elevates the expression of elastin by 4-fold, then elastolysis occurs, Also, the function of the micro-vasculature declines with aging. This is caused by endothelial dysfunction including reduced angiogenic capacity, aberrant expression of adhesion molecules, and impaired vasodilatory function [31, 32].

Cigarette smoking is strongly associated with elastosis in both sexes, and telangiectasia mostly in men. Smoking causes skin damage primarily by decreasing capillary blood flow to the skin, which, in turn, creates oxygen and nutrient deprivation in cutaneous tissues. It has been shown that those who smoke have fewer collagen and elastin fibers in the dermis, which causes skin to become slack, hardened and less elastic. Smoke causes damage to collagen and elastin in lung tissue and may do so in skin as well. In addition, constriction of the vasculature by nicotine may contribute to wrinkling [32].

Smoking increases keratinocyte dysplasia and skin roughness. A clear dose–response relationship between wrinkling and smoking has been identified, with smoking being a greater contributor to facial wrinkling than even sun exposure. Smoking was demonstrated to be an independent risk factor for premature wrinkling even when age, sun exposure and pigmentation were controlled. In addition, although hormone-replacement therapy was demonstrated to reverse wrinkling, the skin of long-time smokers did not respond [31, 32].

Other Lifestyle factors that influence skin aging are temperature and humidity. An increase in skin temperature of 7–8 C° doubles the evaporative water loss. Low temperature stiffens skin and decreases evaporative water loss even with plenty of humidity in air, as structural proteins and lipids in the skin are critically dependent on temperature for appropriate conformation. Some medications affect the skin as well, particularly hypo-cholesterolemic drugs, which may induce abnormal increased desquamation [32].

1.4. Clinical hallmarks of skin aging and treatment modalities

Irregularities in surface texture, pigmentation, and wrinkling are hallmarks of aged skin [33].

1.4.1. Fitzpatrick skin type

The most important factor to consider in patients seeking skin rejuvenation in terms of skin resurfacing techniques is Fitzpatrick skin type (Table 1.1). It is prognostic of developing signs of photo-aging and it is very important to predict the post procedural complications such as, hyper and hypo pigmentation especially in skin types IV-VI, and prolong erythema in skin types I and II [33, 34and 35].

Table.1.1 **Fitzpatrick Skin Type** [35]

Type I	Always burns, never tans, extremely fair complexion
Type II	Always burns, sometimes tans, fair complexion
Type III	Sometimes burns, always tans, medium complexion
Type IV	Rarely burns, always tans, olive complexion
Type V	Never, burns, always tans, medium brown complexion
Type VI	Never burns, always tans, markedly dark brown/black complexion

1.4.2. The Glogau scale

Separates patients into four categories based on cumulative sun exposure and degree of wrinkles associated with aging (Table 1.2).

Although both of these classification systems are useful, they do not provide the physician with all the information needed to select the ideal patient-specific treatment. They precede the advent of non-ablative and fractional ablative technologies and fall short in addressing patients with thicker and darker skin types [33, 34, and 36].

Table 1.2 Glogau Scale [36]

Mild	No wrinkles	No keratosis Wears little to no makeup
Moderate	Wrinkles in motion	Early keratosis, sallow complexion Usually needs makeup
Advanced	Wrinkles at rest	Many actinic keratosis, telangiectasia Always wears makeup
Severe	All wrinkles	Severe keratosis, severe photoaging Wears makeup with poor coverage

1.4.3 Wrinkles assessment scale (WAS)

An increasing number of rejuvenation techniques for facial wrinkles and folds points to the need for objective measurements of their effectiveness. Patient satisfaction is the goal, but proof of the value of a particular product requires objective measurement. A wrinkle assessment scale was developed originally as a simple tool to assess the changes resulting from injecting filler materials and it can be used reliably to assess the result for other rejuvenation techniques. By correlating the grade of the wrinkle in the reference photographs with the wrinkle in a patient’s face, a classification of 0 to 5 according to the severity of the wrinkles and folds for each part of the face such as the forehead, crow's feet, perioral and cheek wrinkles [37], (figures 1.2-1.5)

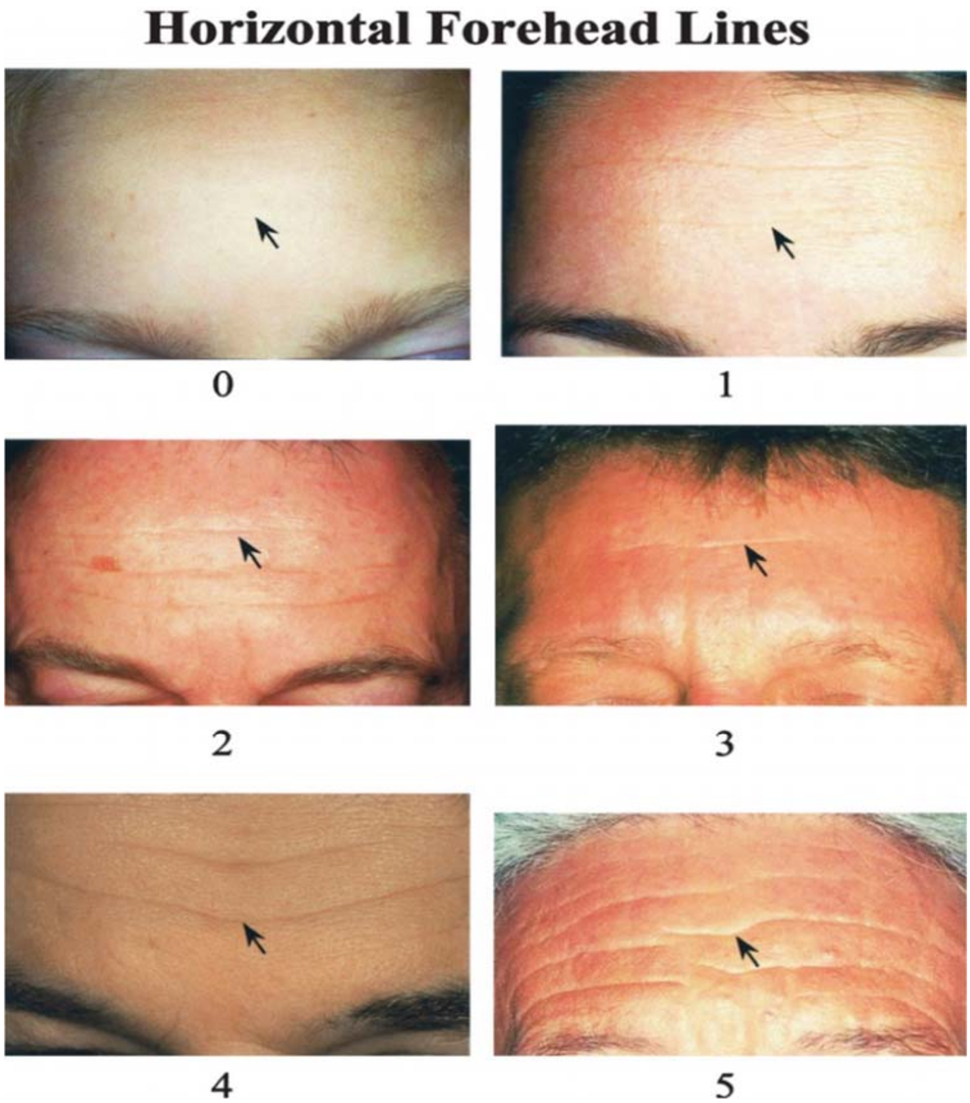


Figure 1.2 WAS. Forehead lines [37].

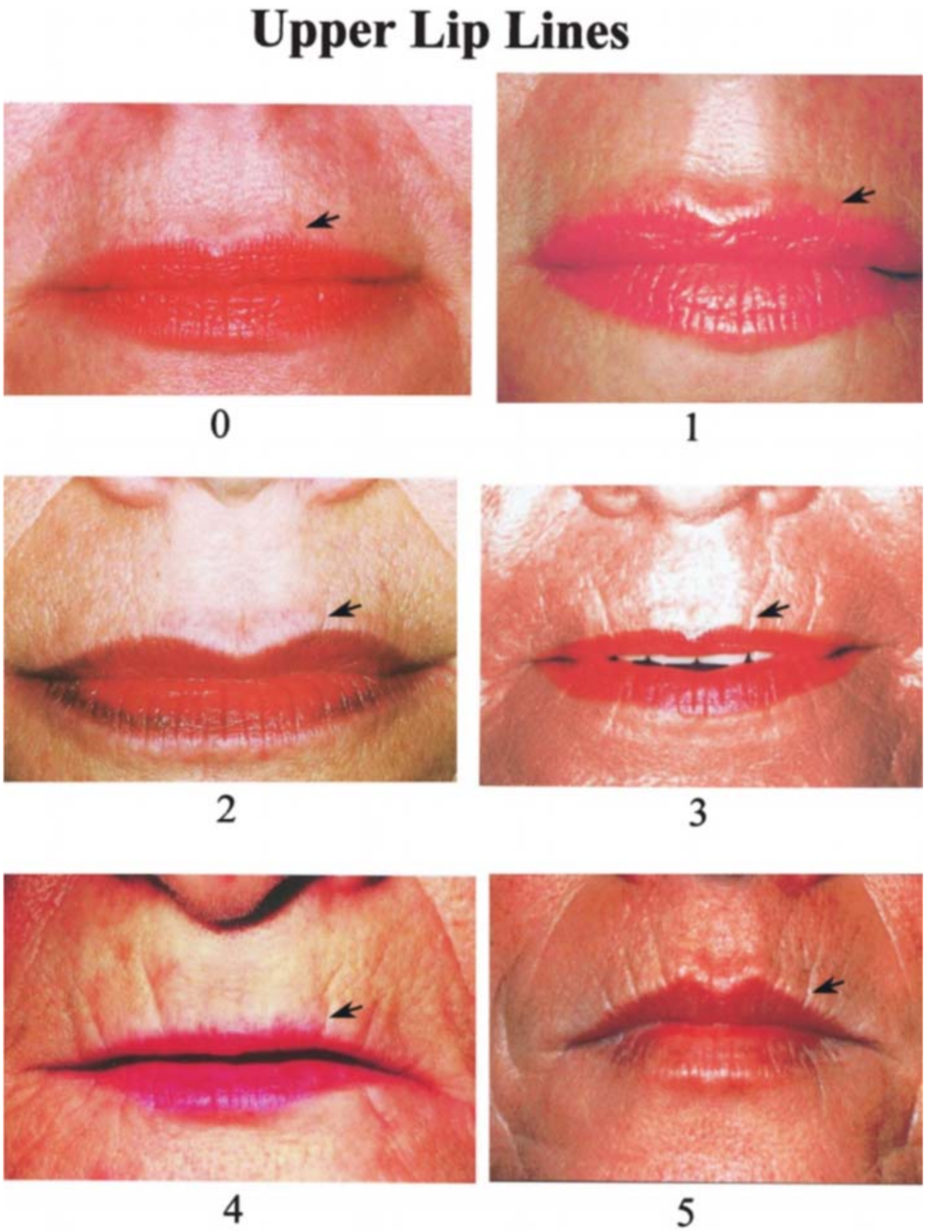


Figure 1.3 WAS. Perioral lines [37].

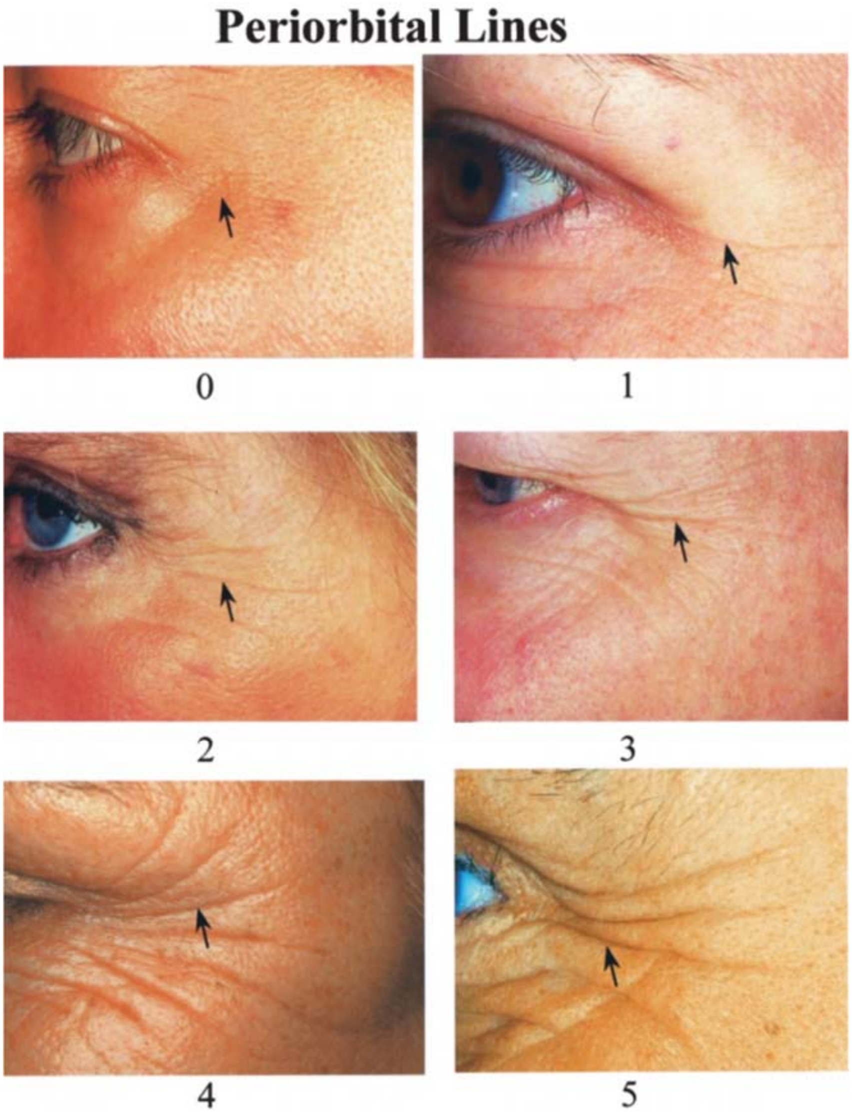


Figure 1.4 WAS. Crow's feet [37].

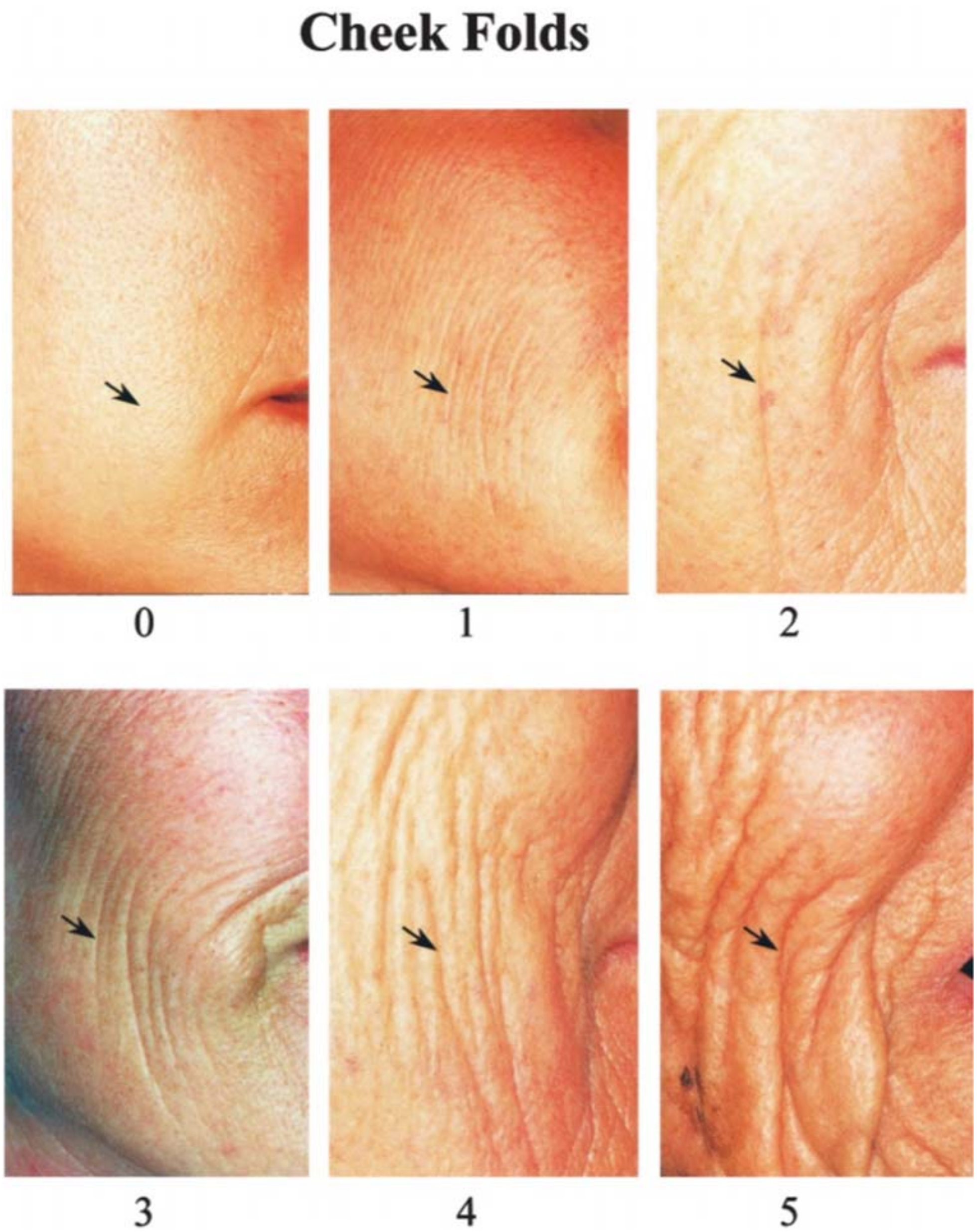


Figure 1.5 WAS. Cheeks lines [37].

1.4.4 Treatments modalities of aging skin.

-Pharmaceutical and skin care modalities, Antioxidants, Retinoids, hormones replacement, diets restrictions, cosmetic and skin care procedures and product [3, 33].

-Minimal invasive surgical techniques, such as stem cells transplant, and fat transplant [1, 3, 33].

-Skin resurfacing techniques, include dermabrasion, chemical peels, and LASER resurfacing [3, 33] which is the core of this research.

1.4.5 Skin resurfacing techniques

Classically, mechanical, chemical, and photodynamic injuries to the skin have been used in a controlled fashion to elicit desired changes. Cutaneous resurfacing targets abnormal skin structures at specific depths causing the body to replace the desired areas with normal healthy tissue to achieve aesthetic goal. The face, neck, décolletage, and hands are subject to the most sun exposure over a lifetime and are the most frequent sites of skin resurfacing. Although multiple modalities exist to achieve similar injury patterns, the patients' present different challenges to achieving the desired aesthetic result. To minimize the risk of complications, an understanding of skin anatomy as it relates to aging and a logical approach to selecting an intervention are of the utmost importance [33].

1.4.6 Wound Healing After Resurfacing Procedures

Resurfacing treatments rely on controlled destruction of targeted layers of the skin past the level of the abnormality, followed by healing and replacement with healthy tissue [34]. The goal is to optimize healing and minimize scarring.

If the injury is isolated to the epidermal layer, an intact basal layer is capable of re-epithelialization without involvement of the underlying dermis. Insults extending into the superficial layer of the dermis repopulate the epidermis in two mechanisms—vertical migration of epithelial cells within dermal appendages (hair follicles and sweat glands) and lateral migration of keratinocyte from adjacent epidermal edges [35, 36]. Deeper injuries within the dermal layer stimulate fibroblast production of new collagen via the classic inflammation, proliferation, and remodeling phases of wound healing. Appropriate remodeling and reorganization of the collagen deposited can result in skin tightening and the decreased appearance of fine lines [33, 35].

1.5 Laser Resurfacing

Laser technology began to develop in the 1960s. The devices use light energy and are classified by wavelength on the electromagnetic spectrum (Figure 1.6). Discovery of selective photo-thermolysis, or the specific affinity of certain wavelengths for different biologic targets or chromophores, ultimately made way for the advent of cutaneous laser resurfacing in the 1980s. The chromophore or target in the treatment of skin resurfacing for fine lines and rhytids is water.

Other chromophores that are popular targets include melanin and dermal hemoglobin. Selective photo thermolysis uses a wavelength that reaches and is preferentially absorbed by the desired chromophore (Figure 1.7). The tissue is then exposed to the energy for a duration equal or less than the time it takes for the target structures to cool, which is called the thermal relaxation time [33, 36]. Sufficient energy must be delivered to damage the target. Laser treatments targeting water produce histological changes similar to those of phenol peels, although the permanence of skin changes following laser treatment remains controversial. Complete photo-rejuvenation requires targeting water, hemoglobin, and melanin. No one laser or wavelength meets all of those objectives on its own [33, 38, and 39].

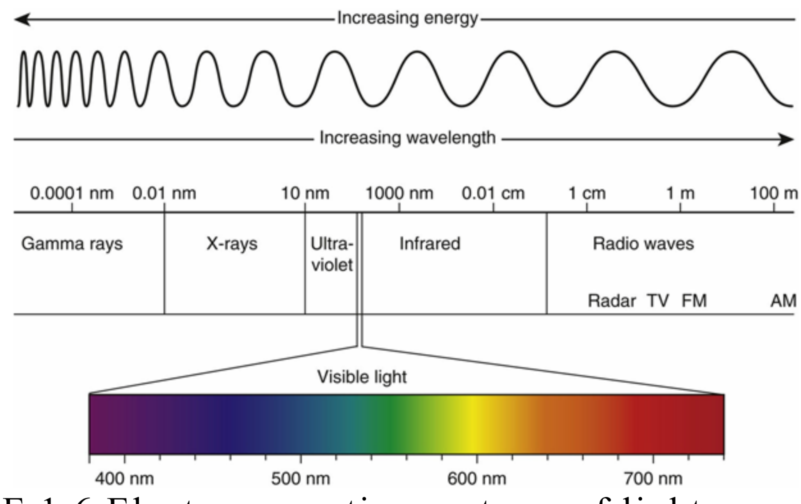


FIGURE 1.6 Electromagnetic spectrum of light wavelengths [33].

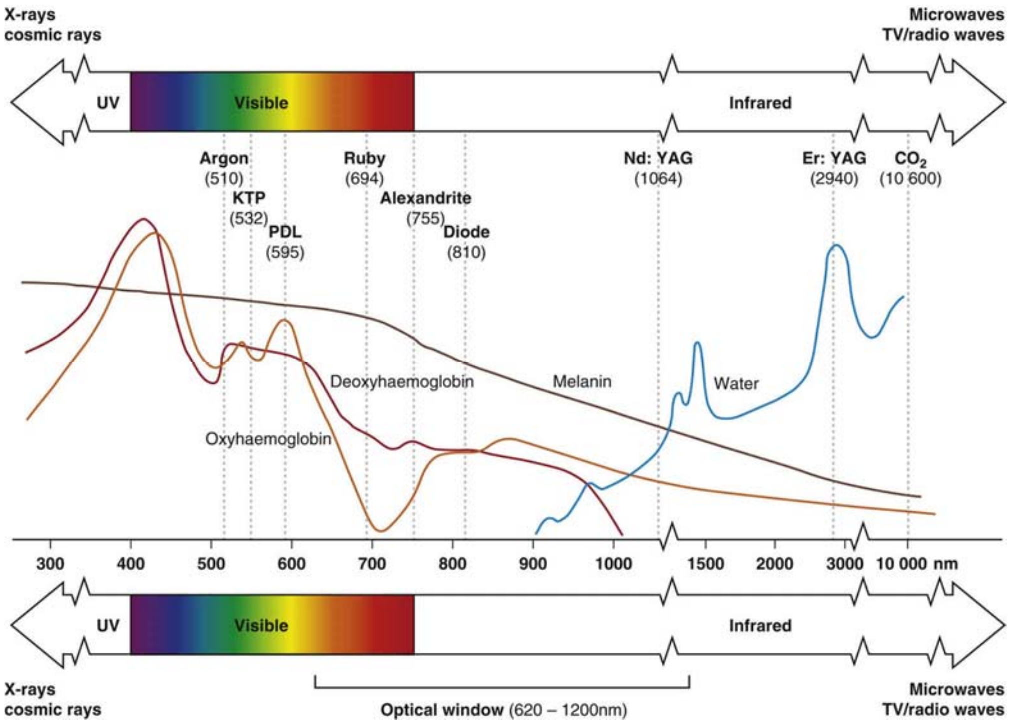


FIGURE 1.7 Chromophore absorption spectrum, illustrating which wavelengths are preferentially absorbed by specific components of the skin [33].

1.5.1. Basic laser principles

Laser is an acronym for light-amplified stimulated emission of radiation. Depending on Einstein principle of stimulated emission of radiation, Lasers generate spatially and temporally coherent electromagnetic radiation of a fixed wavelength focused into a precise beam of energy. Lasers consist of an energy source and a medium housed within an optical cavity (Figure 1.8). The electrons of the atoms within the medium are excited upon exposure to the energy source, commonly a flash lamp. The medium may be a solid, liquid, or gas. As the electrons spontaneously fall from the excited to resting state, photons with medium-specific wavelengths are emitted. Using a system of reflective and semi-reflective mirrors, the emitted photons are redirected back into the medium allowing for:

(1) Excitement of additional electrons within the medium (amplification)

(2) Coherence and collimation due to constructive and destructive interference.

Once a sufficient amount of energy is generated, the laser beam will be allowed to exit the optical cavity. The laser light may be delivered to the tissue by a series of mirrors within an articulating arm or transported along a fiber optic cable [33, 38].

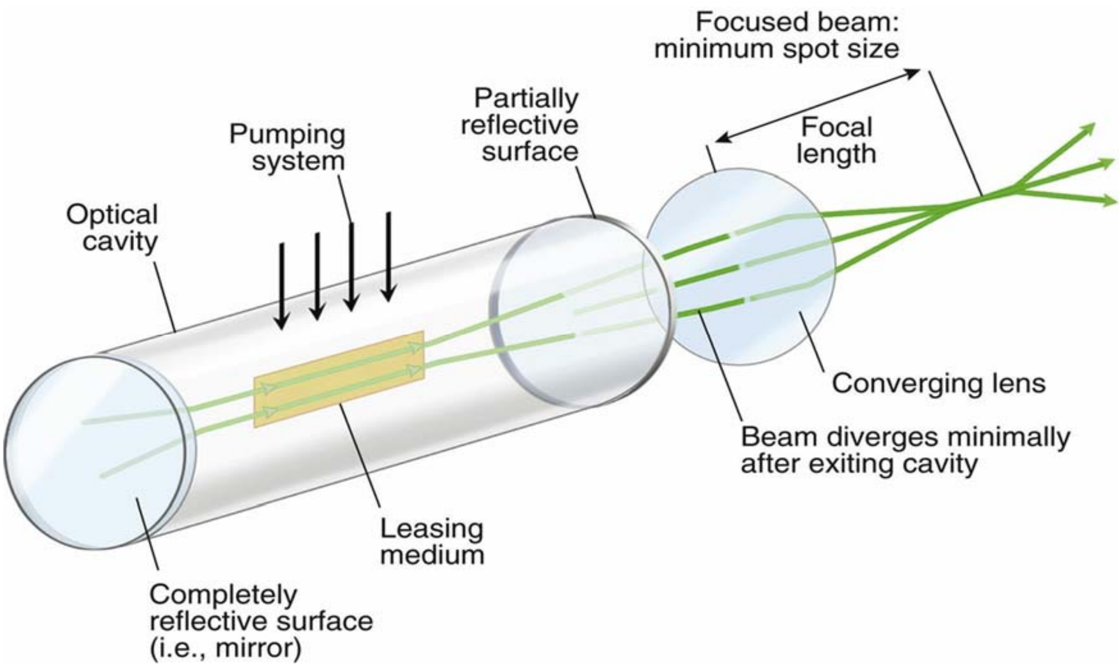


FIGURE 1.8 Components of a laser [38].

1.5.2 Laser-Tissue Interactions

Laser light may be reflected, transmitted, scattered, or absorbed by tissue. The molecules that absorb light are known as chromophores and include hemoglobin, melanin, tattoo pigment, and water. After absorption, chromophores may reemit photons or undergo photo-thermal, photomechanical, or photochemical reactions. Photo-thermal events represent the majority of medical laser reactions and result from an increase of local kinetic energy and the generation of localized heat. Photomechanical reactions result in structural degradation of the chromophore through vibrations following photo-excitation of the chromophore. Photochemical reactions occur when the excited state of the chromophore has markedly different physical or chemical properties than the resting state [38].

1.5.3. Laser parameters

There are several basic parameters that should be considered when performing a procedure using light. Light interaction with tissue is based on absorption and scattering. A beam of light weakens as it moves through scattering surfaces. The dermis is white making it a strongly scattering surface. In general, shorter **wavelengths** have a higher absorption coefficient and penetrate more superficially compared with longer wavelengths (Figure 1.9). Wavelengths in the near-infrared spectrum (740–1300 nm) are absorbed by the darkest shade of gray present in tissue and far infrared spectrum (1300 nm+) wavelengths are absorbed by water as opposed to pigment [33, 38, and 39].

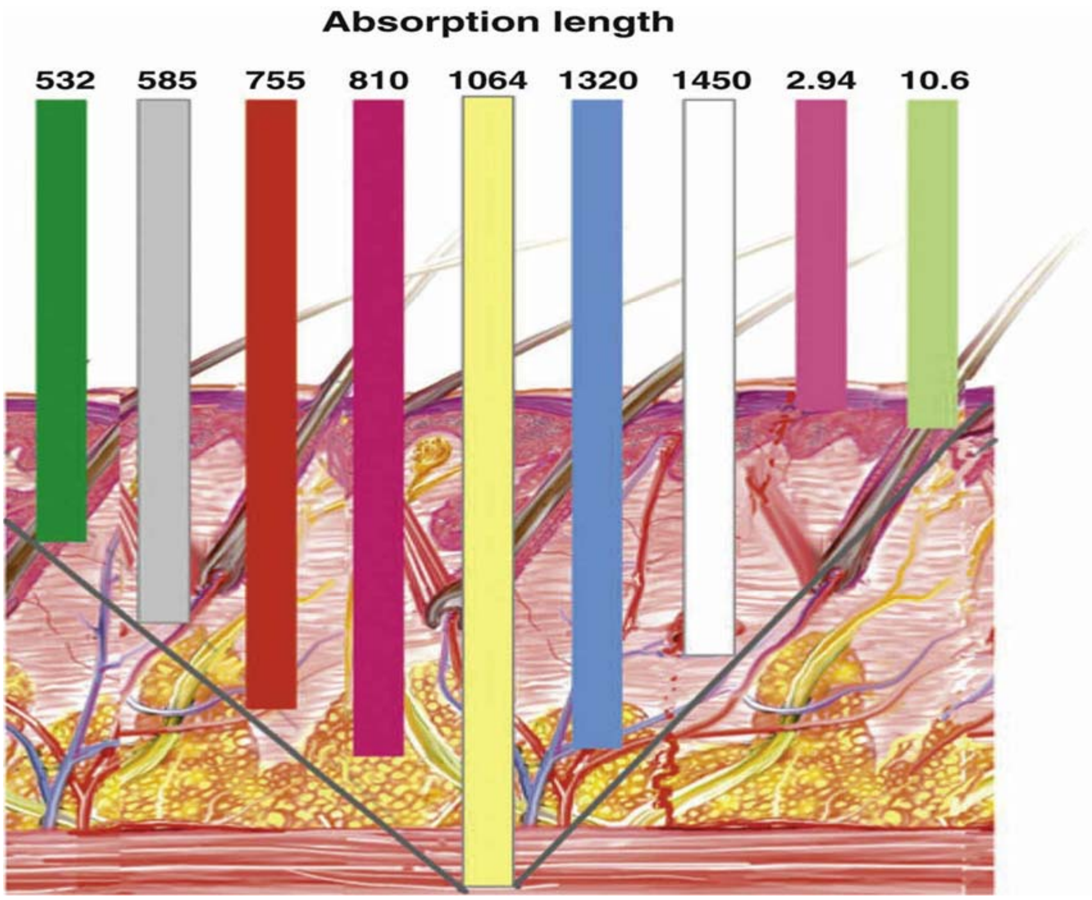


FIGURE 1.9 Illustration demonstrating the penetration depth of multiple wavelength [39].

For continuous wave lasers, important factors include **power**, **time**, and **spot size**, while for pulsed lasers, parameters include **energy per pulse**, **pulse duration**, **spot size**, **fluence** , and **repetition rate**. Energy is measured in joules (J). Power is the rate of energy delivered and is measured in Watts (W = J/s). Spot size (cm2) is the area over which the laser energy is delivered. **Power density** (power/spot size or W/cm2) can be controlled in a manner similar to a magnifying glass by concentrating a given number of photons over a smaller area to increase thermal effect on a target tissue. Thus, decreasing the spot size will increase the power density. However, decreasing spot size also decreases depth of penetration and increases scatter.

To maintain the depth of thermal energy delivered, one must increase the power (rate of energy delivered) as one decreases the spot size (Figure 1.10). For example, a 6 mm spot size and 90 J/cm2 may be needed to close a vessel; if you increase the power density and use a 3 mm spot size instead, the energy needed would increase to 190 J/cm2 to have a similar effect (figure 1.11) [38,40].

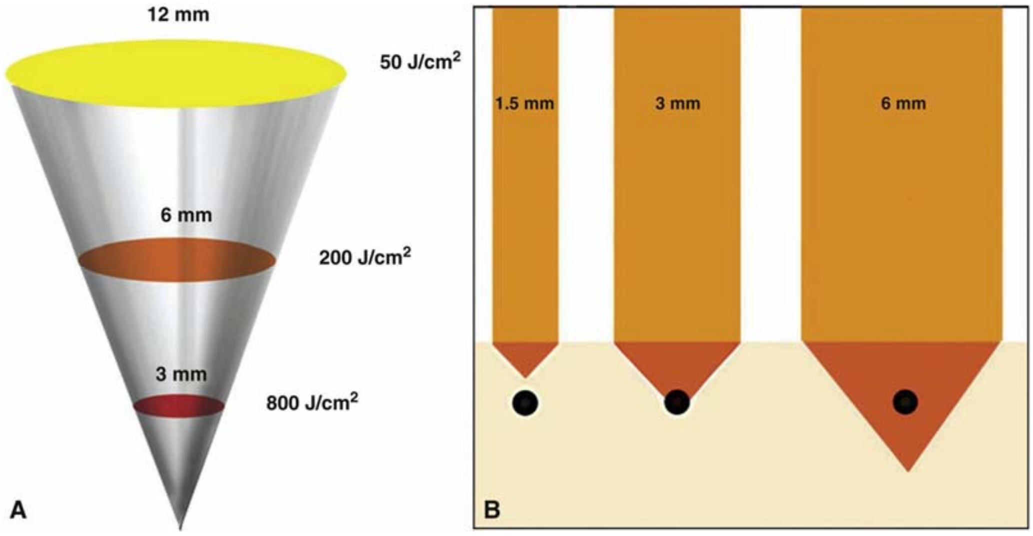


FIGURE 1.10. Power density equals power divided by spot size. A given number of photons are concentrated into an area or spot size. As the spot size decreases, the power density increases. B. Effective treatment zones versus spot size. Depth of penetration is proportionally related to spot size: larger spot sizes allow for deeper absorption of a given wavelength [39].

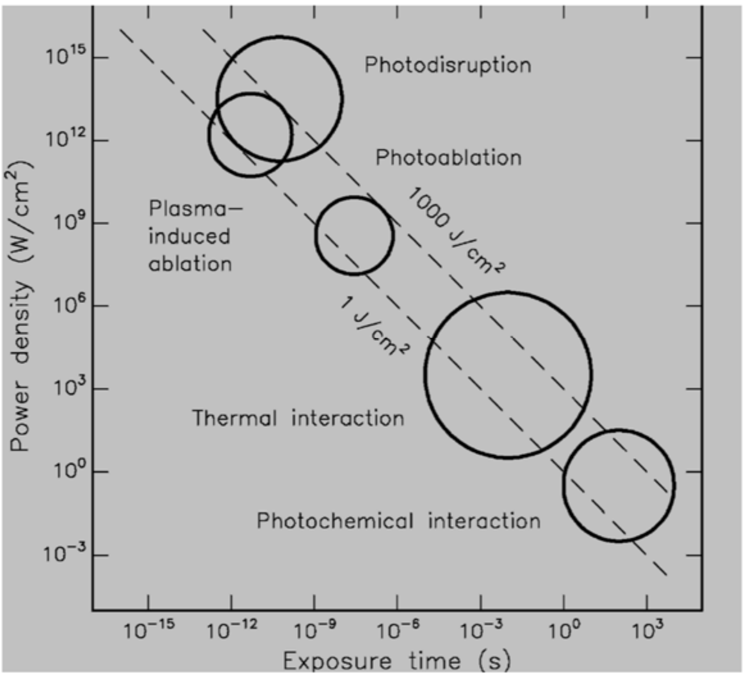


Figure 1.11 map of Laser tissue interaction [40]

Finally, pulse width is the time over which the energy is delivered and represents the duration of laser exposure. The energy must be deposited in the target before the target has time to cool. **Thermal relaxation time** is how long it takes for a target chromophore to release over half of the temperature rise after laser exposure. Larger targets take longer to cool. For example, a 200 to 300 µm hair follicle has a thermal relaxation time of 10 to 100 ms, whereas a 100 µm blood vessel has a thermal relaxation time of 5 ms. Assuming equal power densities are applied, longer pulse durations cause greater collateral damage [33, 34, 40]. The degree of thermal injury and thus tissue response are related to the duration and temperature of exposure. Cell death is more sensitive to temperature than time, as seen when protein denaturation increases linearly with time and exponentially with temperature. Most resurfacing devices convert light or electrical energy to heat. Under 43°C, the skin remains unharmed for as long as 20 minutes. Molecular structural changes occur at temperatures from 43 to 50°C. High temperatures at shorter times (>100°C for 1 ms) can induce cell death as well [38, 39].

Effective laser therapy aims to maximize thermal effect on specific targets while minimizing collateral damage. Selective photo-thermolysis aims to deliver thermal energy to targets with a higher absorption coefficient than the surrounding tissue to minimize damage to non-targeted tissues .When the ratio of light absorption between the chromophore and surrounding tissue is large (>10), there is a desirable advantage. However, when the target is water, which constitutes 65% of the dermis, differential light absorption cannot be manipulated to protect neighboring structures. Other ways to localize temperature elevation to specific targets is to cool surrounding areas or deliver very small beams (fractional methods) [38, 39, and 41].

Surface cooling methods have helped deliver higher energy to targets with less risk of collateral damage and at a deeper depth. Cooling is also important in infrared laser technology to prevent bulk heating of deep tissues. When water is the chromophore, even at low power density, the nature of the target creates the risk of catastrophic tissue damage. Cooling or fractionated techniques must be used to avoid laser-induced top to bottom skin injury [33, 38, and 41].

1.5.4. Types of Laser used in skin resurfacing

Generally speaking, lasers used in skin resurfacing are either **ablative** or **non-ablative** and can be **full field** or **fractionated**. Ablation refers to the uniform destruction of tissue within the epidermis and/or papillary dermis. Non-ablative resurfacing spares epidermal destruction, targeting deeper structures within the dermis (figure 1.12) this triggers collagen remodeling during the process of healing. Fractional photo-thermolysis delivers treatment in core sections or micro-thermal zones, leaving untreated areas in the skin to promote more rapid healing [33, 38, and 41].

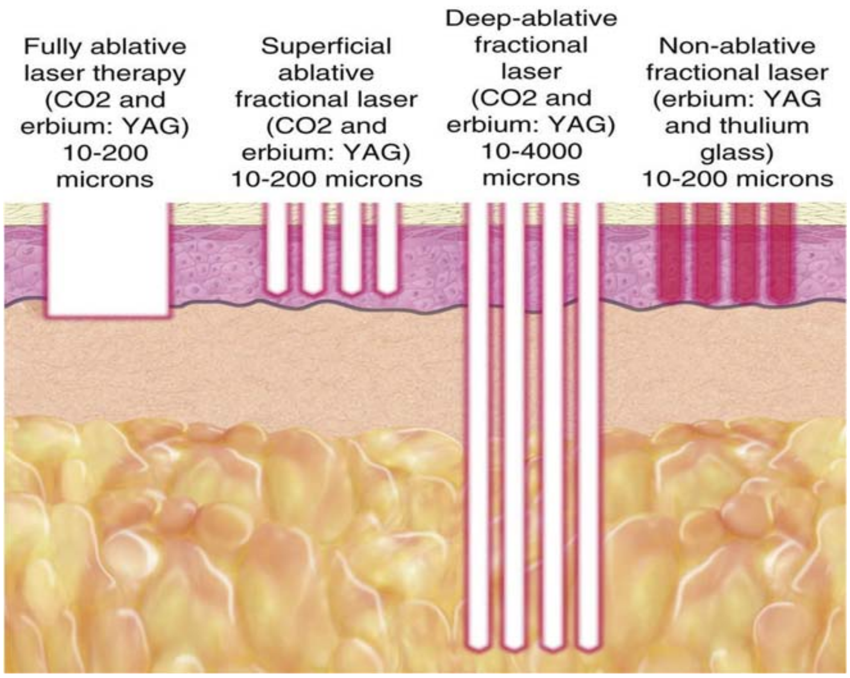


FIGURE 1.12 Overview of ablative and non-ablative laser therapies [38].

1.5.4.1. Erbium-Yttrium-Aluminum-Garnet Laser VS CO_2 Laser

A major advancement was the development of the erbium-yttrium-aluminum-garnet (Er:YAG) 2940-nm wavelength laser. The 2940 nm wavelength has an affinity for water that is nearly 12 to 15 times higher than that of the CO2 laser. This affinity allows Er:YAG to deliver energy to specific depths in the skin without heating the surrounding tissue, thus causing less collateral damage. However, the limited photo-thermal effects of this laser also lead to significantly reduced collagen contraction. Newer Erbium-devices have lengthened the laser pulse duration to induce better tissue contraction. The Er:YAG laser can be used to deliver either coagulation or cool ablation [33]. This is a solid-state laser with a solid rod through which the light is passed. This is different from the CO2 laser that is only a heat-coagulative ablative technology. The cool ablation mode produces a result similar to dermabrasion. In the cool ablative mode, the resulting skin may have thinner dermis, as with dermabrasion. Erbium and CO2 lasers have similar resurfacing results with settings of 50% overlap, 25 to 100 microns of ablation, and 50 to 100 microns of coagulation [33, 39, and 4].

The clinical end point of using the CO2 laser is a chamois color seen with ablation of the papillary dermis and waterlogged cotton thread appearance upon penetration into the reticular dermis.With each additional pass of the CO2 laser, there is a diminishing or plateaued response because the residual carbonized tissue acts as a heat sink. Erbium lasers create less coagulated tissue to absorb heat and make it is easier to drill deeper wounds into the skin with each pass. Following CO2 laser treatment, the desiccated tissue should be wiped off; however, after erbium laser treatment, the barrier is left in place for faster healing and decreased post-treatment pigmentary changes. A split-face study of CO2 and Er:YAG laser resurfacing study demonstrated a 63% improvement on the CO2 laser side with 7.7 days of crusting compared with 48% improvement on the Er:YAG side with 3.4 days of crusting, although these results are highly dependent on depth of treatment and energy used. Ablative lasers are also commonly used to treat acne scarring [42]. Specifically, elevated acne scars are more amenable to ablative resurfacing than icepick or non-distensible surface irregularities. Benign hyperplasias such as rhinophyma and other epidermal proliferations (seborrheic keratosis, actinic keratosis, xanthomas) can be treated with ablative laser therapy. Of note, ablative laser therapy carries the risk of infection (bacterial, viral, and fungal) due to the absence of the protective epidermal barrier. Prophylactic anti-viral treatment should be considered for patient with history of herpetic infection [39].

1.6. Laser safety

A protocol promoting the safety and well-being of the laser surgeon and the patient should be established in every practice. Cases have been reported of fire caused by PDLs, severe eye injury from misguided laser light, and a risk of the laryngeal papillomatosis caused by aerosolized viral particles in laser-generated smoke. The Occupational Safety and Health Administration provides specific information regarding workplace hazards and appropriate countermeasures related to medical laser use [33, 34, and 41].

Categories of safety concern include severe eye injuries from direct or reflected laser light, skin burns from misdirected beams of surgical lasers, and respiratory hazards from laser-generated airborne contaminants.

The American National Standard Institute Z136 series of laser safety standards provides guidance for the safe use of lasers in diagnostic, cosmetic, preventative, and therapeutic applications in health care facilities. These guidelines are considered to be the gold standard for safe practice and are recommended for review and implementation. These standards can be incorporated into a laser safety program that may also include standardized laser safety training for all health professionals working with laser equipment, annual training reviews, quarterly self- inspections, and incorporation of pre-procedure laser safety checklists [38, 42].

1.7. Review of literature

Fractional laser rejuvenation has been developed to overcome the drawbacks of traditional ablative laser. Moetaz et al [43]. Tried to objectively evaluate the effectiveness of multiple sessions of fractional Er:YAG laser rejuvenation for aging upper face clinically, histologically and immune-histochemically, they concluded that, Multiple sessions are effective in rejuvenation of the aging face with high safety, short downtime, and no adverse effects. They stimulated formation of new collagen (type I, III, and VII) up to 6 months after treatment with better improvement in skin texture and fine wrinkles. The variable number of fractional Er:YAG laser sessions (3–5) showed no significant difference as regards efficacy. Matjaz Lukac et al discussed multiple modes of treatments that can be achieved by using fractional, full field multi-stacking micro seconds pulse resurfacing, and the use of long pulse(0.1-1 second) Erb:YAG laser and they concluded that controllable thermal and ablative effects can be achieved by changing the pulse width and the fluence [44].

Emily P. And C. William Hank [45] in objective to review the dermatologic literature on the use of fractional photo-thermolysis for treatment of dyspigmentation. Concluded that ablative and non-ablative fractional photo-thermolysis are potentially effective modalities for the treatment of dyspigmentation of the face and neck and dyschromia associated skin aging.

de Vries, Karin, and Errol P. Prens [46] .showed that fractional ablative Er:YAG and CO2 Lasers are effective treatment for actinic keratosis and photo damaged skin and they are safer than traditional resurfacing techniques in spite of the risk of scaring and dyspigmentation . These risks are lessened very much with the use of fractional lasers. Andrei I. et al [47]. In a literature review was based on a MEDLINE search (1998–2009) for English-language articles related to laser treatment complications and fractional skin resurfacing. Concluded that Complications with fractional laser skin resurfacing represent a full spectrum of severity and can be long lasting. In general, a greater likelihood of developing post-treatment complications is seen in sensitive cutaneous areas and in patients with intrinsically darker skin photo-types or predisposing medical risk factors.

Jeffrey S. Orringer et al [48]. Sought to quantify the molecular changes that result from Er:YAG laser micro-ablative resurfacing. And concluded that, although micro-ablation was confined to the uppermost epidermis, marked changes in epidermal and dermal structure and function were demonstrated after Er:YAG laser micro-ablative resurfacing. They demonstrated substantial dermal matrix remodeling, including a degree of collagen production that compares favorably with some more invasive interventions. Dermal remodeling and stimulation of collagen production are associated with wrinkle reduction. Thus these results suggest that the skin's appearance may be enhanced by creating dermal changes through the use of superficially acting treatments.

Kee-Hsin Chen et al [49]. In A systematic review of comparative studies of CO2 and Erb:YAG lasers in resurfacing facial wrinkles ,concluded: In general, the CO2 laser appeared to be more efficacious then the Er:YAG laser in treating facial wrinkles. Both lasers treatments were well tolerated with the Er:YAG laser was associated with a better complication profile compared with the CO2 laser.

1.8 Aim of the study.

Is to evaluate the efficacy and safety of the use of fractional 2940 nm Er:YAG laser in facial skin rejuvenation

Chapter two

PATIENTS AND METHODS

CHAPTER TWO

PATIENTS AND METHODS

This study was done in Dr. Athir Mahmoud private clinic in Baghdad – Iraq, from 1st of June to the 15th of October 2019.

2.1. Patients description

This study was conducted on 12 female patients with age range from 39 years to 64 years (mean=48.3 years). (Table 2.1). Fitzpatrick skin types II~IV, (table 2.2). Glogau photo aging scale of II~IV,(table 2.3) ,and collective wrinkles assessment scale for the forehead ,crow's feet ,peri oral and cheek wrinkles ranges from 9~16 points .All patients were selected for fractional Er:YAG Laser resurfacing, five of them had upper blepharoplasty between the sessions and during the follow up.

Table 2.1. Age group distribution of the patients

Age group	No. of patients	%
35-40 y.	2	16.66
40-50 y.	6	50
50-60 y.	3	25
60-70 y.	1	8.33
Total	12	100%

Table 2.2. Fitzpatrick skin type distribution of the patients

Fitzpatrick type	No. Of patients	%
Type II	3	25
Type III	7	58
Type IV	2	17
Total	12	100

Table 2.3 Glogau photo aging grades

Grade	No.	%
0	0	0
I	5	41.7
II	6	50
IV	1	8.3
Total	12	100

2.2. Laser system specifications

In this study we used fractional Er:YAG 2940 nm (Lutronic Inc. Fremont, CA, USA)(figures 2.1, 2.2)and (Table 2.4).

Table 2.4 laser system specifications

Performance			System Specification
Laser wavelength			2940 nm
Aiming beam			650 nm <5 mW
Medium of transmission			Er:YAG
Laser transfer method			Articulated arm
Pulse Rate			Single, 1, 2, 5, 10 [Hz]
Pulse Duration		Normal, Fractional, Multiple mode	200 ㎲ ~ 300 ㎲
		Long Pulse mode	200 ㎲ ~ 1.0 s
		Dual mode	1.1s~1.5s
Interval		Normal, Multiple mode	Short (50 ms), 0.2, 0.5, 1.0, 1.5 [s]
		Long Pulse, Fractional mode	Short (100 ms), 0.2, 0.5, 1.0, 1.5 [s]
		Dual mode	0.5, 1.0, 1.5 [s]
Classifications		CDRH Class.	CLASS IV
		Applied Part Class.	B
		MDD Class.	IIb
Spot Size	Zoom Handpiece	Normal mode	1, 2, 3, 4, 5, 6, 7 (mm)
		Long Pulse mode	1.6, 2.4, 3.4, 4.2, 5.0, 5.7, 6.4 (mm)
	[Optional] ShP Handpiece		14 mm
Max. Output power			**3.7 J**
Scanner pattern			**9X9 square**

	[Optional] Fractional Handpiece	ø12, 9x9, 6x6 (mm)
	[Optional] Petit Handpiece 360°	1.0~3.5mm
	[Optional] Petit Handpiece 90°	3.5~5.0mm
Cooling System		Air + Water Cooling
Dimensions		295 x 656 x 1527 (mm)
Display System		8" Touch LCD
Weight		86.5 kg
Electrical rating		Single phase AC100~120V or AC220~230V Fuse 125V/25A or 250V/15A, 50/60Hz Power consumption: 2.2 kVA

Figure 2.1 laser system

Figure 2.2 fractional hand piece

2.3 Consultation

All patients had a consultation prior to the treatment, registering their biographic information such as name, age, sex, occupation, address and contact information. Taking a thorough medical history and physical examination with specific and detailed attention paid to any contraindications. The patient’s Fitzpatrick phenotype and glogau aging stage were documented. The patients provided with detailed information regarding their problem area, the treatment options, risks, benefits, potential complications and anticipated outcomes. It is recommended that:

- The consultation should be used to screen out unsuitable patients for reasons of skin type, skin conditions, any other contraindications and those who cannot complies with post treatment instructions.
- The patient should be provided with information explaining expectations and after care instructions.
- The following key points were communicated to the patients prior to commencing treatment program:
  - Multiple treatments may be required.
  - The effectiveness of treatment is related to skin color, skin type, degree of aging and other factors.
  - The laser type being used and its appropriateness for the patient’s skin type
- Patient's comments were recorded.
- The patients given the opportunity to ask questions and, only when satisfied, the treatment session was scheduled.

- For those patients who are on aspirin, anticoagulant or other medications that may interfere with the laser treatment were instructed to discontinue these medications in accordance with their physician opinion.

2.3.1. Inclusion criteria

All patients were above 35 years old with Fitzpatrick phenotype I to IV with multiple degrees of photo aging (wrinkles, keratosis and pigmentations) and can be committed to avoid direct sunlight exposure for the following ten days after the procedure.

2.3.2. Exclusion criteria and contraindications

- All patients had no previous resurfacing procedure whether laser or conventional resurfacing techniques.
- Patients who received Botulinum A toxin within the last six months.
- Fitzpatrick skin phenotype V and VI.
- patients on anti-coagulants ,steroids ,none steroidal anti-inflammatory drugs ,
- Oral and topical isotretinoin and retinoic acid derivatives for the last 20 days.
- Patients with cancer or other malignant diseases.
- Active herpes simplex.
- Healing disorders such as those caused by connective tissue diseases, radiation therapy, or chemotherapy.
- Photo sensitive skin.
- Psych-neurotic patients.

- Skin allergy to local anesthetics.
- Patients who are unable or unwilling to follow the post treatment instructions
- Patients with unrealistic expectations regarding the clinical outcomes of the treatment.
- Pregnancy.

2.4. Safety measures used during the procedure

The laser system employed in this study is class IV and uses a near infrared 2940 nm laser beam which is invisible to the naked eye. Intra beam and specular reflection exposure may result in serious injury including loss of eyesight. Inappropriate or inadequate protection may cause damage to the eyes. .

Before the procedure the following items where checked:

1- All present during a procedure wear safety goggles for the 2940nm infra-red radiation (figure 2.3).

2- The patients eyes were protected by completely opaque eye cups with additional cotton gauze underneath(figure 2.4)

Figure 2.3 Operator goggles.

Figure 2.4 Patient’s goggles.

2.5. Procedure and method

The treatment consist of two sessions with 1 month apart, at the beginning of each session, cleansing the face of makeup using light makeup remover and water with cotton pads. Taking the pretreatment photographs then applying 10% xylocaine cream for 45-60 minutes then cleaning the face again, the patient admitted to the laser room placed in supine position the patients protective goggles and the cotton gauze were applied. Connecting the fractional hand piece to the articulated arm and connecting the lens cable. Selecting the 1st step parameters (table 2.5), (figure 2.5), the hand piece positioned vertically as possible, the stumping patterns are made with approximately 30% overlap.

Table 2.5 1st step parameters,* micro pulse energy in the fractional mode represents the micro beam energy per pulse.

Hand piece	Fractional(9*9)
Mode	Fractional
Micro pulse energy(mJ)*	8~12
Multi shot	2~3x
Interval(sec, Hz)	Single,1s (=1Hz)
Pulse width (micro sec.)	200

Figure 2.5 first step parameters.

Then the 2nd step parameters selected (table 2.6), (figure 2.6) with disconnecting the hand piece connector to use the fractional hand piece in long pulse mode. After the completion of the first session the patient was given an appointment after 7 days for follow up then another appointment for the second treatment after 3~4 weeks.

At both visits reexamination of the patients was done, taking notes regarding the course of the healing after the first session taking in consideration any adverse event or side effect such as prolong redness, scaring or unwanted pigmentary changes that may necessitate changing the parameters or discontinue the treatment. Afterward the same steps of the treatment are repeated as in the first treatment. The patients were followed up after 1 week after the second session and after 4~8 week for final assessment.

Table 2.6 2nd step parameters.

Hand piece	Fractional
Mode	Long pulse
Pulse width(sec.)	0.6~1
Fluence (J/cm^2)	7~11
Interval(sec, Hz)	Single,0.2sec(=5Hz)

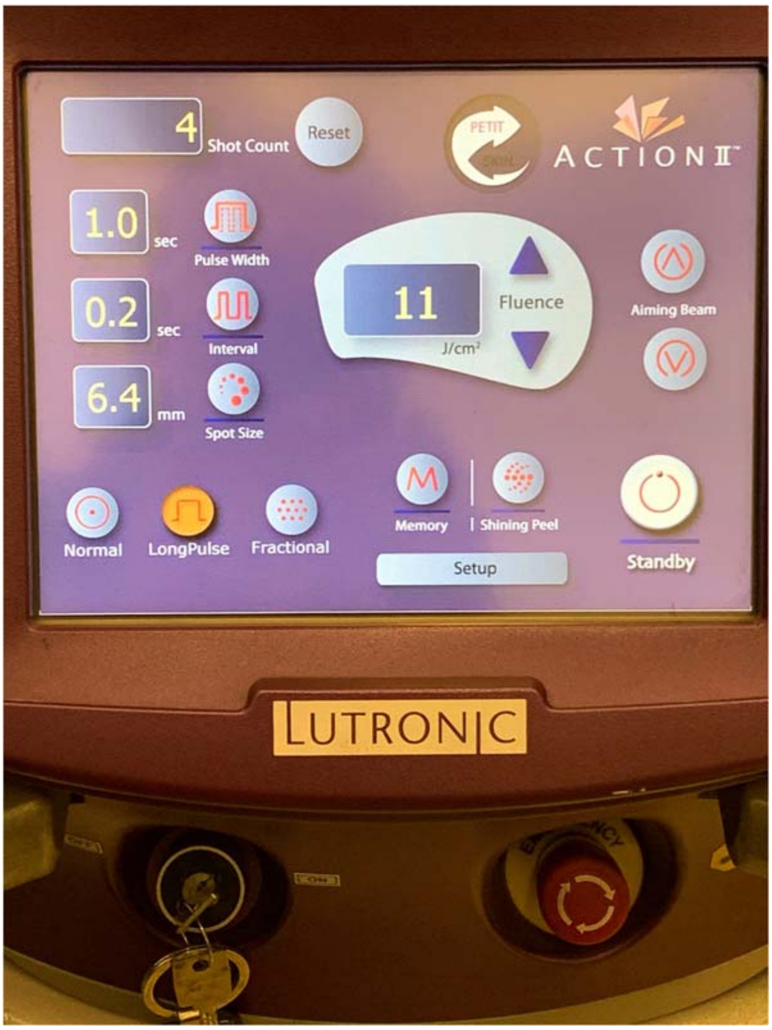


Figure 2.6 second step parameters second step parameters.

2.5.1 Post treatment care and instructions

-Cooling with an ice pack can provide relief to the area from any burning sensation that may occur immediately after the session. Making sure to enclose the ice pack in sterile dry gauze.

- The treated area kept dry for 24 hours. After the first day, gently wash and pat the skin dry for two days. The patients are instructed not to scrub the skin, letting the bronzed skin to separate naturally within 5~7 days.

- Avoidance of cosmetics that contain active ingredients such as Retinol or Alpha Hydroxy Acids (AHA).

- Avoid using alcohol-containing cosmetics for the first week and a mild type skin moisturizing lotion can be used.

- Avoiding exercising for first week post treatment or until initial healing has occurred.

- For at least 20 days after treatment, apply UV-A/B sunblock with SPF more than 30% and PA++++, and use means of protection against sunlight such cap umbrella or any other available protections against sunlight when spending time outdoors.

- 5 patients out of 12with history of herpes simplex were prescribed prophylactic acyclovir tablets 200 mg twice daily for 5 days 1 day before the treatment.

2.6.2 Method of assessment

The photographs that were taken immediately before the first session are reviewed to documents the wrinkle assessment scale by comparing the photographs with the reference photographs and taking the mean score of the right and left side of each area. The reviewing was done by two blinded persons to give the score (table 2.7), the glogau photo aging class was registered and the Fitzpatrick skin type was re checked again after removing the makeup. The degree of dyschromia and keratosis were scaled as mild, moderate and sever (table 2.8).

Table 2.7 wrinkles assessment score before the treatment. (FH=forehead, CF=crow's feet, PO=peri oral, C=cheeks)

Patient's no.	FH	CF	PO	C	SUM
1					
2					
3					
4					

Table 2.8 dyschromia and keratosis degree and percentage.

Patent's no.	Mild	Moderate	Sever
%			

In the second visit the adverse effects after the first treatment is recorded.

When the patients finished the second session they were reassessed after 1~2 months by the wrinkles assessment score, degree of improvement of the dyschromia and keratosis (table 2.9) and the most important factor, the degree of patient satisfaction(table 2.10).

Table 2.9 Degree of dyschromia and keratosis improvement and percentage.

Patient's no.	Mild	Moderate	Good	Excellent
%				

Table 2.10 Patients satisfaction percent

Patient's no.	Unsatisfied	Moderately satisfied	Well satisfied
%			

.

CHAPTER THREE

RESULTS

&

DISCUSSION

3.1 Result

As mentioned in the previous chapter we used the overall patients' satisfaction, the wrinkles assessment scale and the degree of improvement of the dyschromia and keratosis which was assessed by the physician.

- **The patient's satisfaction** was checked after 6~8 weeks (mean=6.4 weeks) after the final session, the patient's satisfaction was about the degree of improvement of the wrinkles, keratosis, the homogeneity of the skin and the overall look. The results was classified as unsatisfied, moderately and well satisfied, the results came as shown in table 3.1.

Table 3.1 Patients satisfaction percent.

Patient's no.	Unsatisfied	Moderately satisfied	Well satisfied
1	-	-	+
2	-	-	+
3	-	-	+
4	-	+	-
5	-	-	+
6	-	-	+
7	-	+	-
8	-	-	+
9	+	-	-
10	-	-	+
11	-	-	+
12	-	-	+
%	8.4%	16.6%	75%

- **The degree of dyschromia and keratosis improvement** was assessed by the physician and scaled as mild (0~25%), moderate (25~50%), good (50~75%) and excellent (>75%. For dyschromia the results were, mild 16.7%, moderate 33.3%, good 33.3%, and excellent 16.7%.

For keratosis the results were, mild 8.3%, moderate 25%, good 41.7%, excellent 25%, (table 3.2 and 3.3).

Table 3.2 Degree of dyschromia improvement

Patient's no.	Mild	Moderate	Good	Excellent
1	-	-	+	-
2	-	-	+	-
3	-	-	-	+
4	+	-	-	-
5	-	+	-	-
6	-	-	+	-
7	-	+	-	-
8	-	-	-	+
9	+	-	-	-
10	-	+	-	-
11	-	-	+	-
12	-	+	-	-
%	16.7%	33.3%	33.3%	16.7%

Table 3.3 Degree of keratosis improvement

Patient's no.	Mild	Moderate	Good	Excellent
1	-	-	-	+
2	-	-	+	-
3	-	-	+	-
4	-	+	-	-
5	-	+	-	-
6	-	-	+	-
7	-	+	-	-
8	-	-	-	+
9	+	-	-	-
10	-	-	-	+
11	-	-	+	-
12	-	-	+	-
%	8.3%	25%	41.7%	25

The improvement in the **wrinkles assessment scale** was calculated by taking the mean score of the right and left sides, before and after the treatment of the forehead (FH), crow's feet (CF), peri oral (PO) and cheeks (C) (table 3.4), the average improvement for the aforementioned areas and the total score down grade was calculated by subtracting the averages of the post treatment for each area of all patients from the pretreatment averages and the same done for the total score, (table 3.5.),

Table 3.4 Wrinkles assessment scale before and after treatment

	Before					After				
No.	FH	CF	PO	C	Sum	FH	CF	PO	C	Sum
1	2.5	2.5	2	3	10	1.5	1.5	1	1.5	5.5
2	3.5	3	3	2.5	12	1.5	1.5	2	1	6
3	3.5	4	3.5	4	15	1.5	2	2.5	2	8
4	3	3.5	4	3.5	14	2	2	3	1.5	8.5
5	2.5	3	3.5	3	11.5	1.5	1	2	1	5.5
6	3	3.5	4	3.5	14	1	1.5	2.5	2	7
7	2.5	3.5	3.5	2.5	12	1.5	2	2.5	1.5	7.5
8	3.5	4	4	3.5	15.5	2	2	2.5	1.5	8
9	4	4	4.5	3.5	16	2	3.5	3.5	2.5	11.5
10	3	3.5	3.5	4	14.5	1.5	1.5	2.5	2	7.5
11	2.5	3	2	1.5	9	1	1	1	0.5	3.5
12	2.5	3.5	3.5	3	12.5	1.5	1.5	2	2	7
AVERAGES	3	3.42	3.42	3.125	13	1.5	1.75	2.25	1.58	7.125
	Mean= 3.24					Mean= 1.77				

Table 3.5 Averages of grades before and after treatment and grades of improvement.

Area	Pre	Post	Improvement
FH	3	1.5	1.5
CF	3.42	1.75	1.67
PO	3.42	2.25	1.17
C	3.125	1.58	1.545
Total	13	7.125	5.875

3.1.1 Adverse effects and complications

- Pain, the procedure was basically painless, except of uncountable burning sensation that lasts for 60~90 minutes which was effectively alleviated by ice packs.

- Redness, all patients had redness that was subsided within 2~3 days, no prolonged erythema was encountered (figure 3.1).

- Neither hyper-pigmentation nor hypo-pigmentation was detected.

- Milia recorded in one patient.

- regarding **infections ,**one patient had flare up of herpes simplex in the upper lip which was subsided within 7 days ,neither bacterial nor fungal infections was encountered.

- No burns or scaring. (Table 3.6)

A **B**

C **D**

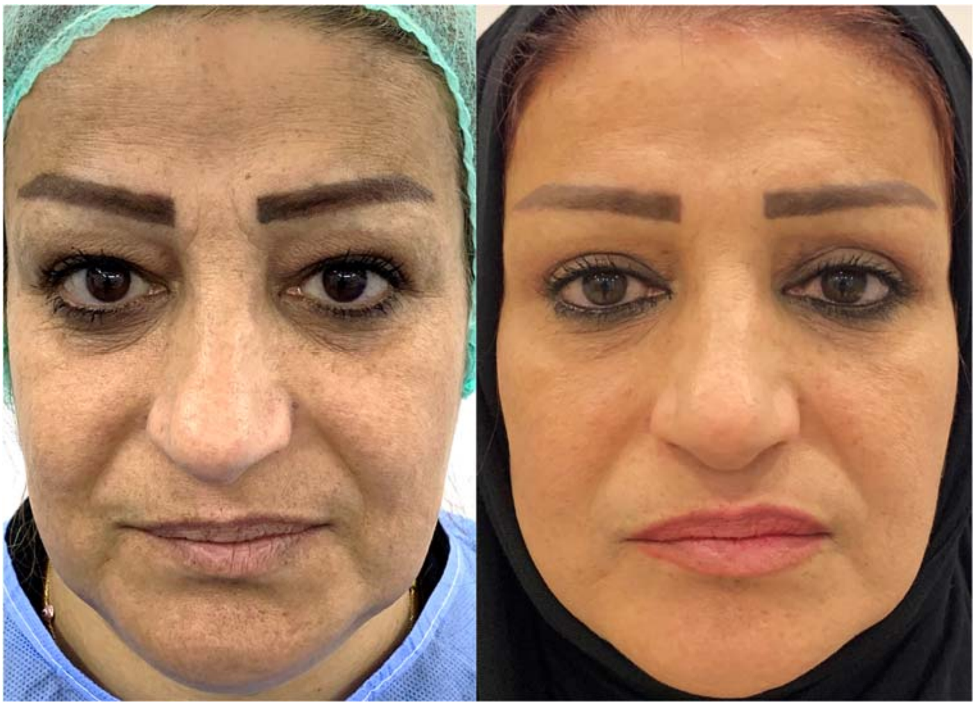
Figure 3.1 before (A), immediately after, (B), 2nd day(C), 10th day (D), upper lip herpetic lesion shown in (D).

Table 3.6 Incidence of complications.

Complications	No. of patients	%
Prolonged erythema	0	0
Hyper-pigmentation	0	0
Hypo-pigmentation	0	0
Milia	1	8.3
Infections	1	8.3
Scaring	0	0
Total	2/12	16.6

3.2. Photographs

Figures (2.1- 2.5) shows photographs of four patients included in this study before and after Erb:YAG rejuvenation, case no.1 had upper blepharoplasty 14 days after the first session and case no.4 had also upper blepharoplasty but 3 weeks after the second session.



A **B**

Figure 3.2 case no.1, 47 years old patient, before (A), after treatment with upper blepharoplasty (B).

A B

Figure 3.3 case no.2, 45 years old patient, before (A), after (B)

A B

Figure 3.4 case no.3, 64years old patient, before (A), after (B)

Figure 3.5 case no.4, 59 years old patient, before (A), after treatment with upper blepharoplasty.

3.3 Discussion

The facial rejuvenation is an important part of the cosmetic medicine and surgery, with an increasing demands in the last decade in our community, due to the progressive availability of the new less invasive rejuvenation technologies with short down time and affordable costs for a wide range of social classes, the increasing awareness for the importance of the skin care and rejuvenation and their impacts on the people's self-esteem, social life and even the job market.

The mean age of the patients in this study was 48.3 years which is relatively not very old, this is related to the effect of climate especially the high UV index throughout the year, pollution, bad dietary habits, high prevalence of smoking and the lack of the idea or the concepts of the early skin care, protection and healthy lifestyle.

Four patients had upper blepharoplasty between and after the treatment sessions to correct the droopy upper eye lid skin, enlarged preaponeurotic fat pads and to reposition herniating lacrimal gland (figure 3.6), those patients were well satisfied with the final results. Combining Erb:YAG resurfacing and skin rejuvenation with aesthetic facial surgeries such as face lift brow lift or blepharoplasties is very common to obtain a perfect cosmetic results [38].

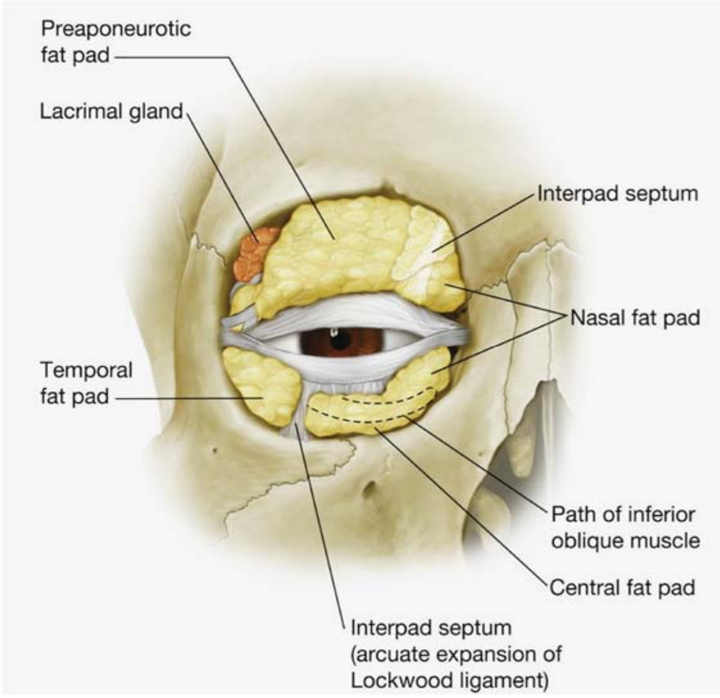


Figure 3.6 Anatomy of the orbital fat pads and lacrimal gland [38]

All the patients in this study were females, this is partly due to the fact that females are seeking cosmetic procedures more than males and can complies with the post treatment instructions better than males, and especially 75% of the patients in this study were retired or unemployed. Although males were not excluded from the study but all of them were unable to be committed with the avoidance of sun exposure.

Skin rejuvenation using resurfacing techniques is well established concept for a long time but the older methods such as dermabrasion and chemical peels lost their popularity after the introduction of the laser resurfacing with excellent and well predictable depth control.

The high energy short pulse carbon dioxide laser full field resurfacing became very popular in the mid-1990s with an impressive results, was compromised with high permanent side effects such as scaring and hypo-pigmentation [41].

The introduction of the first fractional device in the 2004 which was applied to the carbon dioxide lasers and later on to the Erb:YAG lasers opened the door to a wide range of laser treatments [49].

The Erb:YAG 2940 nm have 10 times greater water absorption than the 10600 nm CO2 laser and 3 times the 2700 nm Erb:YSGG so the penetration of the 2940 nm is 10~40 μm according to the parameters used compared to more than 100 μm penetration of the CO2 , this give the privilege of more precise ablation depth control over other ablative lasers with subsequent less side effects ,of course this came on the expense of the necessity to more passes to attain the same end point of other lasers [44].

When very large ablation depths are desired, the MULTI-STACKING or TURBO mode technology can be used, this mode allows the practitioner to determine the treatment depth by selecting the fluence and the number of pulses to be stacked on the same treatment area, this allows to reaches depths up to 100 μm without pronounced thermal effect as far as the pulse width in the μ second and this is the principle of the 1st step treatment parameters [44].

Another addition is the VARIABLE PULSE WIDTH technology of the fractional Erb:YAG laser which increases the versatility of the treatment modes, by increasing the pulse width in the range of 0.2~1sec. With sub ablation fluences which are 7~11 J/cm^2 corresponding to 0.2~1sec. pulse width, there will be no ablative instead there will be thermal effect, the thermal depth extends far beyond the optic penetration depth. This controlled fractional thermal effect will cause subcoag and subsequent collagen stimulation and rearrangement [44]. This was the principal of the 2nd step treatment parameters.

Any laser system have shortcomings including the system used in this study which were:

1- **Prolonged treatment time,** which was about 30~45 minutes this due to the small stumping area of the fractional hand piece, this may necessitate the use of larger scanning patterns.
2- **Noise,** due to the explosive laser-tissue interaction of the ablative Erb:YAG laser.

Regarding the results of this study (table 3.1), shows that 75% of patients were well satisfied, 16.6% were moderately satisfied and 8.3% were unsatisfied this is comparable to published studies [50, 51] .

In table 3.2 which in lists the degree of dyschromia improvement, 50% of the patients had good to excellent results versus 50% who had mild to moderate improvement. This is due to the fact that the Erb:YAG laser is more effective in ablating the epidermal pigmentary lesions, whereas the deeper junctional and dermal melanosis such as melasma and post inflammatory Hyperpigmentation may require deeper full field ablation with high rate of complications, or the use of Q switched Nd:YAG 1064 nm laser in multiple low fluenc sessions [33, 38, 47].

The improvement in keratosis was good to excellent in 66.7% of patients compared to 33.3% of patients who were mildly to moderately improved. The hyper keratotic lesions are epidermal and therefore are more prone to the ablation [46], (table 3.3). The results for the dyschromia and hyper keratosis was assessed by the physician satisfaction so they cannot be compared to other studies objectively.

The mean improvement in Wrinkles assessment scale was 1.5 points for the forehead, 1.67 points for the crow's feet, 1.17 points for the peri oral region, 1.545 points for the cheeks and the overall improvement was 5.875 points and mean improvement of all regions 1.47 points, (table 3.4 and 3.5). The results are close to each other except for the peri oral region which was the lowest to improve this is due to the strong effect of the orbiculares muscle, mentalis muscle and the depressor anguli oris muscle those muscles accentuate the vertical lines around the lips, deepening the labiomental crease and slanting down the lateral oral crease, another factor bad vertical around the lips in females is the lack of the mustache hair follicles which give support to this area makings these lines are much less prevalence in males compared to females. So the resurfacing alone is not enough to improve this area, additional neurotoxin, filler or fat grafting can give excellent results [33, 52].

Complications that raised after the Erb:YAG laser rejuvenation was16.6%, one patient (8.3%) had herpes simplex infection although she did not gave a history of previous infection and one patient(8.3%) had milia. Hyper pigmentation, hypo pigmentation, prolong erythema and scaring were not recorded. Our results was variable and it was irrelevant to compare it to published articles.

However Metelitsa et al [47] reviewed fractionated lasers complication on a MIDLINE search and they find that:

- Prolonged erythema (in the term of more than one month) rate was 12.5% and patients with Fitzpatrick phenotype I were very prone to this complication.

-The rate of herpes simplex virus (HSV) infection, the most common type of infection after fractional laser skin resurfacing, has been reported in 0.3% to 2% of cases. The rate of bacterial infection with fractionated skin resurfacing, with only 0.1% of all treated cases documented to develop impetigo [47].

-Although rarely seen, cutaneous candidiasis induced by Candida albicans is the most common fungal infection reported after fractional laser skin resurfacing [47].

-Incidence of milia development has been reported in as many as 19% of treated patients with fractional lasers [47].

-Post inflammatory hyper pigmentation is much less frequent with fractional laser skin resurfacing than with other ablative procedures but is observed in 1% to 32% of patients, depending on the system used, treatment parameters applied, and skin photo types treated. Hypopigmentation is an extremely uncommon complication of fractional laser skin resurfacing [47].

-Hypertrophic scarring is a known and rare complication of ablative skin resurfacing using CO2 and Er:YAG lasers [47].

3.4 Conclusions and recommendations

- combining fractional ablative and fractional non ablative long pulse Erb:YAG laser is effective and reliable rejuvenation tool, results in improvement of Wrinkles, dyschromia, keratosis as well as improve the skin tone and it is recommended to be used for facial rejuvenation with mean improvement of 14.71 points.

- The procedure has high safety profile compared to other resurfacing procedures.

- The shallow penetration necessitate multiple passes to achieve the required ablation depth, and of course longer treatment time, so we recommend the use of multi stacking mode and wider scanning patterns.

- Combining other rejuvenation modalities such as neurotoxins and fillers will give perfect results especially for the poorly improved areas.

- Erb:YAG resurfacing is very effective adjuvant technique to aesthetic surgical procedures such as fat grafting, blepharoplasty, brow lift and face lift to achieve maximum satisfactory results.

- For comparable results we need to include larger numbers of patients and to follow up them for longer period of time because full results may need more than two months to achieve and some complications such as hypo pigmentation may show after the two months of follow up.

- More sessions may be needed to be studied.

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الخلاصة

الخلفية: ان استعمال ليزر ال Er:YAG المجزأ في علاج التجاعيد و شيخوخة الجلد الناتجة عن التعرض لضوء الشمس في تزايد مستمر ، وذلك بسبب قلة نسبة الخطورة الى نسبة الاستفادة من استعمال هذا الليزر.أن تقنية النظام المتعدد الضربات و تقنية النبضة المتغيرة الطول فتحت آفاق واسعة في طرق استعمال هذا الليزر في مجال اعادة الحيوية والشباب لبشرة الوجه.

الهدف من الدراسة: لتقييم فعالية وأمان استعمال ليزر ال Er:YAG المجزئ ذو الطول الموجي ٢٩٤٠نانومتر في عمليات تسطيح الجلد واعادة الحيوي للوجه.

طريقة الدراسة والمواد: تضمنت الدراسة ١٢ سيدة معدل أعمارهن ٤٨,٣ سنة يعانين من دراجات متفاوتة من علامات شيخوخة الجلد وتضرر الجلد الناتج عن التعرض لاشعة الشمس، جميعهن خضعن لجلستين علاجيتين تفصل بينهما مدة شهر واحد، كل جلسة تضمنت خطوتين ،الخطوة الأولى كانت بأستعمال نظام الليزر المجزأ الحتي المتعدد الضربات والخطوة الثانية باستعمال نظام الليزر المجزأ طويل النبضة غير الحتي. تم تقييم النتائج بعد مرور ٤ الى ٨ أسابيع بعد الجلسة الثانية عن طريق استعمال مقياس تقييم التجاعيد ،نسبة تحسن التصبغات، نسبة تحسن التقرن السفعي، نسبة رضاء المرضى عن النتائج و نسبة المضاعفات المصاحبة للعلاج.

النتائج: معدل تحسن مقياس تقييم التجاعيد كان مرضي جدا وتحسن التقرن السفعي كان جيد الى ممتاز بنسبة ٦٦،٧٪ وقليل الى متوسط بنسبة ٣٣،٣٪ ، اما نسبة تحسن التصبغات فقد كانت ٥٠٪ جيد الى ممتاز و ٥٠٪ قليل الى متوسط، ٧٥٪ من السيدات المشاركات في الدراسة كنّ راضيات جدا عن النتائج، ١٦،٦ كنّ راضيات بصورة متوسطة و ٨،٣ منهن لم يكنّ راضيات عن النتائج،اما بخصوص المضاعفات المصاحبة للعلاج فقد كانت نسبتها ١٦،٦٪ حيث كانت هناك حالة إصابة بقوباء الشفة وحالة إصابة بالدُخَينات .

الأستنتاج: ان إستعمال ليزر ال Er:YAG بنظام الليزر المجزأ الحتي و المجزأ طويل النبضة غير الحتي في عملية إعادة الحيوية والشباب للوجه هو إستعمال آمن، فعال، وذو فترة نقاهة قصيرة مع نسبة مضاعفات منخفضة.

وزارة التعليم العالي والبحث العلمي

جامعة بغداد معهد الليزر

للدارسات العليا

تجديد شباب الوجه بأستخدام ليزر ال Er:YAG المجزء

دارسة مقدمة إلى معهد الليزر للدارسات العليا / جامعة بغداد
كجزء من متطلبات نيل درجة الدبلوم العالي في تطبيقات الليزر في الطب/ الجراحة التجميلية

من قبل

علي عبدالجليل كاظم

دبلوم عالي جراحة تجميلية

بكالوريوس طب وجراحة عامة

بإشارف

الدكتور أثير محمود عبدعلي السعد
بورد عراقي جراحة تقويمية
دبلوم عالي في تطبيقات الليزر

١٤٤١هـ **٢٠١٩م**