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Treatment of facial acne scar using Fractional Er:YAG laser

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

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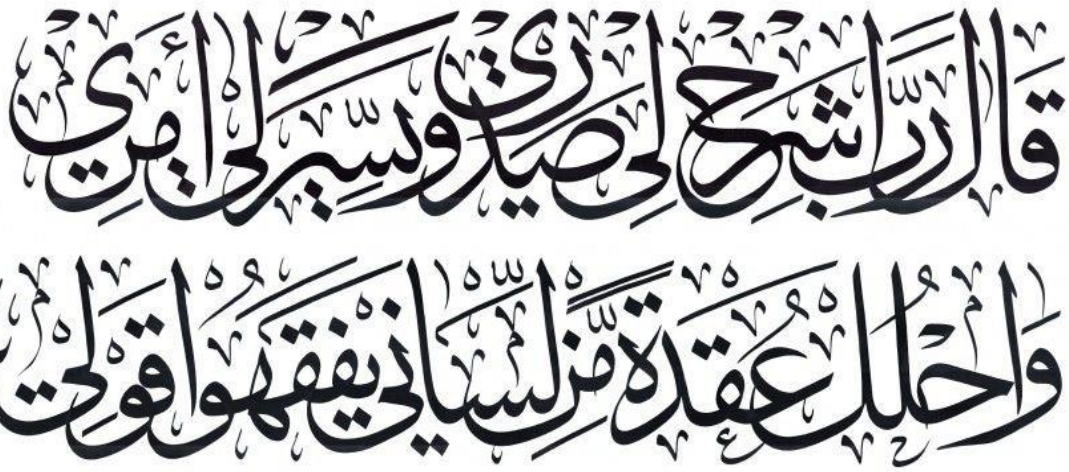
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Dedication

To the memory of my mother she always believed in me, to my father , my family , my wife , my daughter, and my son thank you for your support and impatience throughout my study time.

ABSTRACT

Background: Acne is a common disorder experienced by adolescents and persists into adulthood in approximately 12%–14% of cases with psychological and social implications of high gravity. Fractional resurfacing employs a unique mechanism of action that repairs a fraction of skin at a time. The untreated healthy skin remains intact and actually aids the repair process, promoting rapid healing with only a day or two of downtime.

Aims: This study, was designed to evaluate the safety and effectiveness of fractional photothermolysis (fractionated Erbium: YAG laser 2940nm) in treating atrophic acne scars.

Methods: 7 females and 3 males with moderate to severe atrophic acne scarring were enrolled in this study that attained private clinic for Dermatology and Laser in Baqubah city of Diyala - Iraq during the period from 1st of June 2019 to 10th of October 2019. Fractional Erbium:YAG laser 2940 nm wavelength was delivered to the whole face with a single pass treatment and for the acne scar areas with two passes. Therapeutic outcomes were assessed by standardized digital photography.

Results: Three patients (30%) reported excellent improvement, five patients (50%) significant improvement, one patient (10%) moderate improvement, and one patient (10%) mild improvement in the appearance of the acne scars.

Conclusion: Fractional Erbium: YAG a safe and effective option for the treatment of acne scars in Iraqi patients by offering faster recovery time with no or mild side effects in comparison to other traditional modalities.

Keywords: Atrophic acne scar, Fractional Er: YAG laser.

LIST OF ABBRIVIATIONS

AFR	Ablative fractional resurfacing
ANSI	American National Standards Institute
CD	Cluster of Differentiation
cm	Centimeter
cm^2	Squired centimeter
CO2	Carbon Dioxide
Er:YAG	Erbium: Yttrium-Aluminum-Garnet
FP	Fractional photothermolysis
HeNe	Helium Neon
Hz	Hertz
IL-	Interleukin
J	Joule
LASER	Light amplification by stimulated emission of radiation
MASER	microwave amplification by stimulated emission of radiation
mJ	Milli joule
mm	Millimeter
MMP-13	Matrix metalloproteinase-13
mS	Millisecond
mW	Milli watt
nm	nanometer
OD	Optical density
PDL	Pulsed dye laser
PPAR	Peroxisome proliferator activated receptor
PRP	Platelet rich plasma
Sec.	Second
SPSS	Statistical package for social sciences
TLR	Toll-Like receptors
W	watt
µS	Microsecond

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Introduction

1.1. Acne scar

Acne has a prevalence of over 90% among adolescents and persists into adulthood in approximately 12%–14% of cases with severe psychological and social implications of high gravity [1].

Several factors are incriminated in the pathogenesis of acne including increased sebum production, follicular abnormal keratinization, colonization with *Propionibacterium acnes*, and a lymphocytic and neutrophilic inflammatory response. All body areas with high concentrations of pilosebaceous glands are involved, but in particular the face, back and chest. Inflammatory acne lesions can result in permanent scars, the severity of which may depend on delays in treating acne patients. The prevalence and severity of acne scarring in the population has not been well studied, although the available literature is usually correlated to the severity of acne [2]. In the general population nearly 1% of people had acne scars, although only 1 in 7 is considered to have “disfiguring scars”, Severe scarring caused by acne is associated with substantial physical and psychological distress, particularly in adolescents[3].

1.2. Anatomy of the skin:

The skin is the largest organ of the body accounting about 15% of total adult body weight, it performs many vital functions including protection against external physical, chemical, and biological assailants as well as prevention of excess water loss from the body and role of thermoregulation[4].

1.2.1. Layers of skin:

The skin is composed of three layers as shown in figure (1-1):

- The epidermis.

- The Dermis.

- And subcutaneous tissue.

The outer most layers is the epidermis which consists of specific constellation of keratinocyte cells which function to synthesis keratin, along thread like protein with protective role. The middle layer, the dermis is fundamentally made up of fibrillar structural protein known as Collagen. The dermis lie on subcutaneous tissue, which contain small lobes of flat cells known as Lipocytes. The thickness of these layers varies considerably depending on geographic location of the body. Ex: eye lid is thinnest epidermal layer. Palm and sole have the thickest epidermal layer [4].

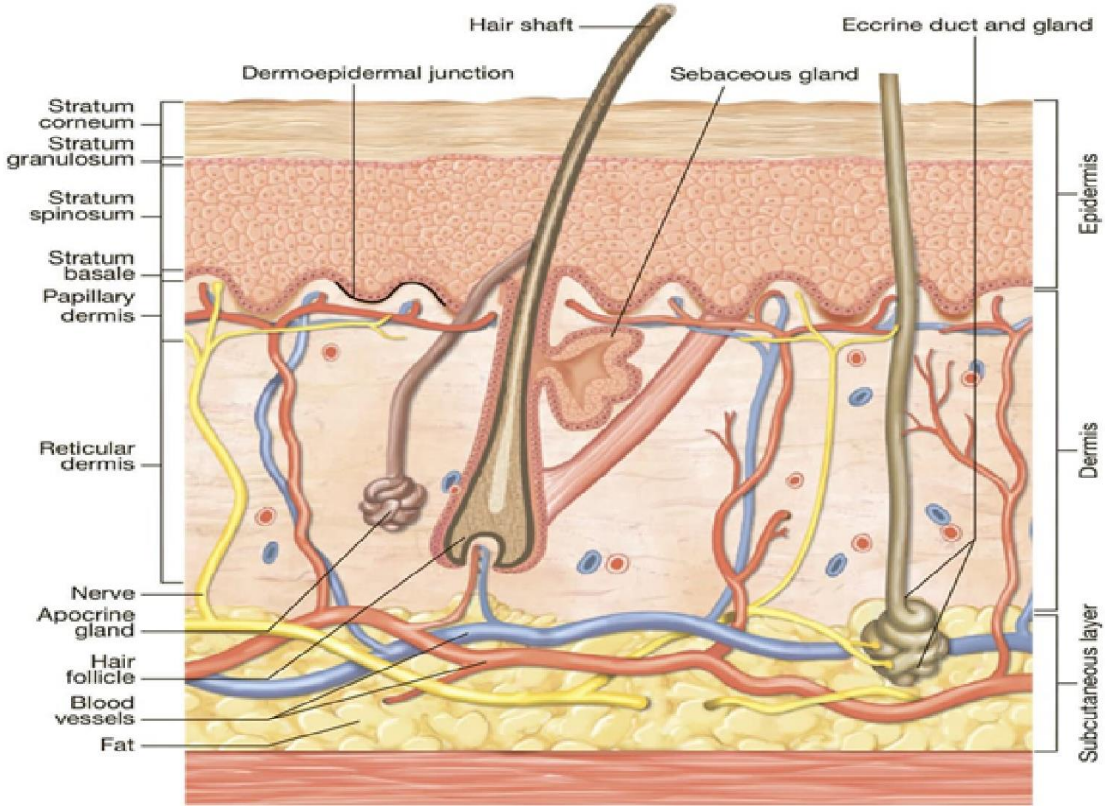


Figure (1-1): Anatomy of the skin [5].

1.2.2. Skin types

Ideal candidates for laser resurfacing have fair skin of Fitzpatrick types I to III (Table 1.1). All patients may be candidates for laser resurfacing, regardless of skin color. Patients with fair skin (types I and II) and with thick, sebaceous skin are more likely to have prolonged erythema [6].

TABLE (1-1) Fitzpatrick classification of skin type [6].

Type I	Type II	Type III	Type IV	Type V	Type VI
White skin. Always burns, never tans.	Fair skin. Always burns, tans with difficulty.	Average skin color. Sometimes mild burn, tan about average.	Light-brown skin. Rarely burns. Tans easily.	Brown skin. Never burns. Tans very easily.	Black skin. Heavily pigmented. Never burns, tans very easily

1.3. Pathogenesis of Acne scar:

The pathogenesis of acne is currently attributed to multiple factors, such as increased sebum production, alteration of the quality of sebum lipids, androgen activity, proliferation of Propionibacterium acnes (P. acnes) within the follicle and follicular hyper keratinization. Increased sebum excretion contributes to the development of acne. Neutral and polar lipids produced by sebaceous glands serve a variety of roles in signal transduction and are involved in biological pathways. Additionally, fatty acids act as ligands of nuclear receptors such as PPARs. Sebaceous gland lipids exhibit direct pro- and anti-inflammatory properties, whereas the induction of 5-lipoxygenase and cyclooxygenase-2 pathways in sebocytes leads to the production of proinflammatory lipids .Furthermore, hormones like androgens control sebaceous gland size and sebum secretion. In cell culture, androgens only promote sebocytes proliferation, whereas PPAR ligands are required for the induction of differentiation and lipogenic activity [7].

On the other hand, keratinocytes and sebocytes may be activated by P. acnes via TLR, CD14, and CD1 molecules. Pilosebaceous follicles in acne lesions are surrounded by macrophages expressing TLR2 on their surface. TLR2 activation leads to a triggering of the transcription nuclear factor and

thus the production of cytokines/chemokines, phenomena observed in acne lesions. Furthermore, P. acnes induces IL-8 and IL-12 release from TLR2 positive monocytes.

All these events stimulate the infrainfundibular inflammatory process, follicular rupture, and perifollicular abscess formation, which stimulate the wound healing process. Injury to the skin initiates a cascade of wound healing events. Wound healing is one of the most complex biological process and involves soluble chemical mediators, extracellular matrix components, parenchymal resident cells as keratinocytes, fibroblasts, endothelial cells, nerve cells, and infiltrating blood cells like lymphocytes, monocytes, and neutrophils, collectively known as immunoinflammatory cells. Scars originate in the site of tissue injury and may be atrophic or hypertrophic. The wound healing process progresses through 3 stages:

1- Inflammation,

2- Granulation tissue formation, and

3- Matrix remodeling [8].

1.4. Morphology, Histology, and Classification of acne scar

Scarring can occur as a result of damage to the skin during the healing of active acne. There are two basic types of scar depending on whether there is a net loss or gain of collagen (atrophic and hypertrophic scars). 80% to 90% of people with acne scars have scars associated with a loss of collagen (atrophic scars) compared to a minority who show hypertrophic scars and keloids [9].

1.4.1. Atrophic acne scars are more common than keloids and hypertrophic scars with a ratio 3:1. They have been subclassified into icepick, boxcar, and rolling scars (Figure 1-2 and Table 1-2). With atrophic scars, the ice pick type represents 60%–70% of total scars, the boxcar 20%–30%, and rolling scars 15%–25% [9].

Icepick: narrow (2mm), punctiform, and deep scars are known as icepick scars. With this type of scar, the opening is typically wider than the deeper infundibulum (forming a “V” shape) (Figure 1-2).

Rolling: dermal tethering of the dermis to the subcutis characterizes rolling scars, which are usually wider than 4 to 5 mm. These scars give a rolling or undulating appearance to the skin (“M” shape).

Boxcar: round or oval scars with well-established vertical edges are known as boxcar scars. These scars tend to be wider at the surface than an icepick scar and do not have the tapering V shape. Instead, they can be visualized as a “U” shape with a wide base. Boxcar scars can be shallow or deep (table 1-2). Sometimes the 3 different types of atrophic scars can be observed in the same patients and it can be very difficult to differentiate between them. For this reason several classifications and scales have been proposed by other authors. Goodman and Baron proposed a qualitative scale and then presented a quantitative scale [10].

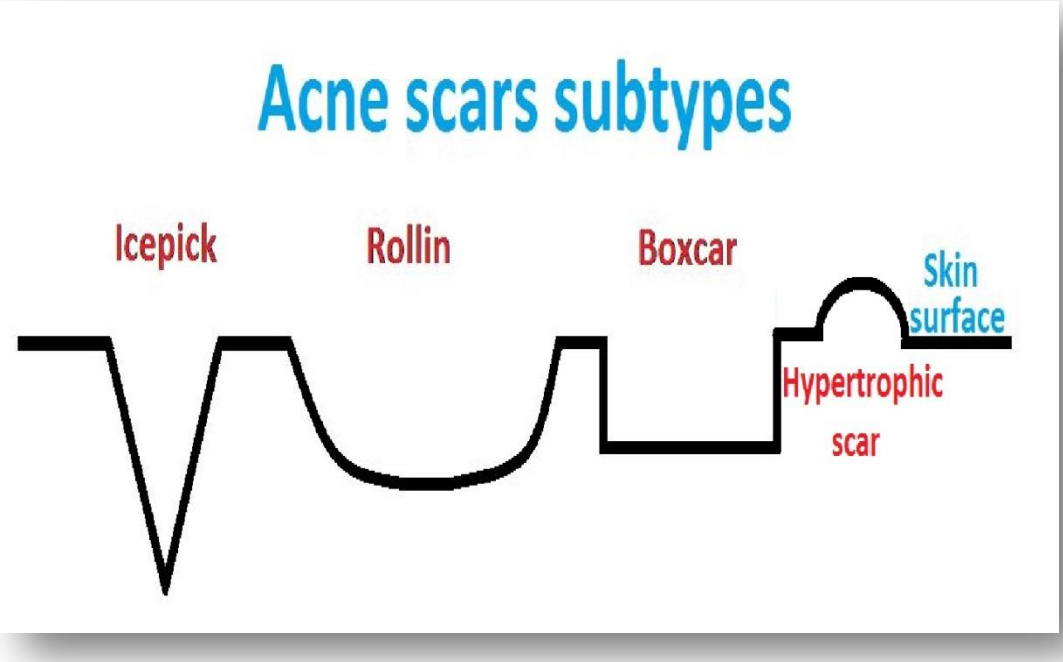


Figure 1-2 acne scar subtypes (adapted from [9])

Table (1- 2) Acne scar morphological classification (adapted from [9]).

Acne Scars subtype	Clinical Feature
Icepick	Icepick scars are narrow [<2mm], deep, sharply marginated epithelial tracts that extend vertically to the deep dermis or subcutaneous tissue.
Rolling	Rolling scars occur from dermal tethering of otherwise relatively normal-appearing skin and are usually wider than 4 to 5mm. abnormal fibrous anchoring of the dermis to the subcutis lead to superficial shadowing and a rolling or undulating appearance to the overlying skin.
Boxcar Shallow < 3mm > 3mm	Boxcar scars are round to oval depressions with sharply demarcated vertical edges, similar to varicella scars. They are clinically wider at the surface than icepick scars and do not taper to a point at the base.
Deep < 3mm > 3mm	They may be shallow (0.1–0.5mm) or deep (≥0.5mm) and are most often 1.5 to 4.0mm in diameter.

The qualitative scarring grading system proposed by Goodman and Baron [7] is simple and universally applicable. According to this classification, four different grades can be used to identify an acne scar, as shown in Table (1-3).

Table 1-3: Goodman's qualitative global scarring grading system. [10]

Grades of post acne scaring	Level of disease	Clinical feature
1	Macular	These scars can be erythematous, hyper-or hypo pigmented flat marks. They do not represent a problem of contour like other scar grades but of color.
2	Mild	Mild atrophy or hypertrophy scar that may not be obvious at social distances of 50 cm or greater and may be covered adequately by makeup or the normal shadow of shaved beard hair in men or normal body hair if extra facial
3	Moderate	Moderate atrophic or hypertrophic scar that is obvious at social distances of 50 cm or greater and is not covered easily by makeup or the normal shadow of shaved beard hair in men or normal body hair if extra facial, but is still able to be flattened by manual stretching of the skin
4	Sever	Sever atrophic or hypertrophic scar that is evident at social distances greater than 50 cm and is not covered easily by makeup or the normal shadow of shaved beard hair in men or normal body hair if extra facial, and is not able to be flattened by manual stretching of the skin.

1.4.2. Hypertrophic and Keloid Scars. Hypertrophic and keloid scars are associated with excess collagen deposition and decreased collagenase activity. Hypertrophic scars are typically pink, raised, and firm, with thick hyalinized collagen bundles that remain within the borders of the original site of injury. The histology of hypertrophic scars is similar to that of other dermal scars. Incontrast, keloids form as reddish-purple papules and nodules that proliferate beyond the borders of the original wound; histologically, they are characterized by thick bundles of hyalinized acellular collagen arranged in whorls. Hypertrophic and keloidal scars are more common in darker-skinned individuals and occur predominantly on the trunk [10].

1.5. Treatment of acne scars:

New acquisitions by the literature have showed that prevention is the main step in avoiding the appearance of post-acne scars. Genetic factors and the capacity to respond to trauma are the main factors influencing scar formation [10]. A number of treatments are available to reduce the appearance of scars. First, it is important to reduce as far as possible the duration and intensity of the inflammation, thus stressing the importance of the acne treatment. The use of topical retinoids is useful in the prevention of acne scars but more than any other measure; the use of silicone gel has a proven efficacy in the prevention of scars, especially for hypertrophic scars and keloids.

1.5.1. Non laser therapy

1.5.1Atrophic Scars

1.5.1.1. Chemical Peels. By chemical peeling we mean the process of applying chemicals to the skin to destroy the outer damaged layers and accelerate the repair process . Chemical peeling is used for the treatment of skin lesions as well as scars, particularly acne scars. Dyschromias wrinkles, and acne scars are the major clinical indications for facial chemical peeling . As regards acne scars, the best results are achieved in macular scars. Icepick and rolling scars cannot disappear completely and need sequential peelings together with homecare treatment with topical retinoids and alpha hydroxy acids [11].

(A) Glycolic Acid. Glycolic acid is an alpha-hydroxy acid, soluble in alcohol, derived from fruit and milk sugars. Glycolic acid acts by thinning the stratum corneum, promoting epidermolysis and dispersing basal layer melanin. It increases dermal hyaluronic acid and collagen gene expression by increasing secretion of IL-6 . The best results achieved for acne scars regard five sequential sessions of 70% glycolic acid every 2 weeks [11].

(B) Jessner's Solution. Formulated by Dr. Max Jessner, this combination of salicylic acid, resorcinol, and lactic acid in 95% ethanol is an excellent superficial peeling agent. Resorcinol is structurally and chemically similar to phenol. It disrupts the weak hydrogen bonds of keratin and enhances penetration of other agents. Lactic acid is an alpha hydroxy acid which causes corneocyte detachment and subsequent desquamation of the stratum corneum .As with other superficial peeling agents, Jessner's peels are well tolerated [11].

(C) Pyruvic Acid. Pyruvic acid is an alpha-ketoacid and an effective peeling agent .It presents keratolytic, antimicrobial and sebostatic properties as well as the ability to stimulate new collagen production and the formation of elastic fibers. The use of 40%–70% pyruvic acid has been proposed for the treatment of moderate acne scars [19].

(D) Salicylic Acid. Salicylic acid is one of the best peeling agents for the treatment of acne scars .It is a beta hydroxyl acid agent which removes intercellular lipids that are covalently linked to the cornified envelope surrounding cornified epithelioid cells. The most efficacious concentration for acne scars is 30% in multiple sessions, 3–5 times, every 3-4 weeks [12].

(E) Trichloroacetic Acid. The use of trichloroacetic acid (TCA) as a peeling agent was first described by P.G. Unna, a German dermatologist, in 1882. TCA application to the skin causes protein denaturation, the so-called keratocoagulation, resulting in a readily observed white frost. For the purposes of chemical peeling, it is mixed with 100mL of distilled water to create the desired concentration. TCA in a percentage of 10%–20% results in a very light superficial peel with no penetration below the stratum granulosum; a concentration of 25%–35% produces a light superficial peel with diffusion encompassing the full thickness of the epidermis; 40%–50% can produce injury to the papillary dermis; and finally, greater than 50% results in injury extending to the reticular dermis. Unfortunately the use of TCA concentrations above 35% TCA can produce unpredictable results

such as scarring. When performed properly, peeling with TCA can be one of the most satisfying procedures in acne scar treatment but it is not indicated for dark skin because of the high risk of hyperpigmentation [13].

1.5.1.2. Dermabrasion/Microdermabrasion. Dermabrasion and microdermabrasion are facial resurfacing techniques that mechanically ablate damaged skin in order to promote reepithelialization. Dermabrasion completely removes the epidermis and penetrates to the level of the papillary or reticular dermis, inducing remodeling of the skin's structural proteins. Microdermabrasion, a more superficial variation of dermabrasion, only removes the outer layer of the epidermis, accelerating the natural process of exfoliation. Both techniques are particularly effective in the treatment of scars and produce clinically significant improvements in skin appearance. Dermabrasion is performed under local or general anesthesia. Unlike dermabrasion, microdermabrasion can be repeated at short intervals, is painless, does not require anesthesia and is associated with less severe and rare complications, but it also has a lesser effect and does not treat deep scars. It is essential to conduct a thorough investigation of the patient's pharmacological history to ensure that the patient has not taken isotretinoin in the previous 6–12 months. As noted by some studies, the use of tretinoin causes delayed reepithelialization and development of hypertrophic scars [14].

1.5.1.3. Punch Techniques. Atrophic scarring is the more common type of scarring encountered after acne. Autologous and nonautologous tissue augmentation, and the use of punch replacement techniques has addedmore precision and efficacy to the treatment of these scars . The laser punch-out method is better than even depth resurfacing for improving deep acne scars and can be combined with the shoulder technique or even depth resurfacing according to the type of acne scar. Laser skin resurfacing with the concurrent use of punch excision improves facial acne scarring [15].

1.5.1.4. Dermal Grafting. Acne scars may be treated surgically using procedures such as dermabrasion and/or simple scar excision, scar punch elevation, or punch grafting . The useful modalities available are dermal punch grafting, excision, and facelifting. The selection of these techniques is dependent on the above classification and the patient's desire for improvement. Split-thickness or full-thickness grafts "take" on a bed of scar tissue or dermis following the removal of the epidermis. The technique is useful in repairing unstable scars from chronic leg ulcers or X-ray scars. It can also camouflage acne scars, extensive nevi pigmentosus, and tattoos . It is prepackaged dermal graft material that is easy to use, safe, and effective [15].

1.5.1.5. Tissue Augmenting Agents. Fat transplantation. Fat is easily available and it has low incidence of side effects .The technique consists of two phases: procurement of the graft and placement of the graft. The injection phase with small parcels of fat implanted in multiple tunnels allows the fat graft maximal access to its available bloody supply. The fat injected will normalize the contour excepted where residual scar attachments impede this [15].

1.5.1.6. Other Tissue Augmenting Agents. There are many new and older autologous, nonautologous biologic, and nonbiologic tissue augmentation agents that have been used in the past for atrophic scars, such as autologous collagen, bovine collagen, isolagen, alloderm, hyaluronic acid, fibrel, artecoll, and silicon, but nowadays, because of the high incidence of side effects, the recommended material to use is hyaluronic acid [15].

1.5.1.7. Needling. Skin needling is a recently proposed technique that involves using a sterile roller comprised of a series of fine, sharp needles to puncture the skin. At first, facial skin must be disinfected, then a topical anesthetic is applied, left for 60 minutes. The skin needling procedure is achieved by rolling a performed tool on the cutaneous areas affected by

acne scars backward and forward with some pressure in various directions. The needles penetrate about 1.5 to 2mm into the dermis. As expected, the skin bleeds for a short time, but that soon stops. The skin develops multiple micro bruises in the dermis that initiate the complex cascade of growth factors that finally results in collagen production [16].

1.5.1.8. Silicone Gel. Silicone-based products represent one of the most common and effective solutions in preventing and also in the treatment of hypertrophic acne scars. The silicone gel was introduced in the treatment of hypertrophic acne Scars to overcome the difficulties in the management of silicone sheets. Indeed, the silicone gel has several advantages: it is transparent, quick drying, nonirritating and does not induce skin maceration; it can be used to treat extensive scars and uneven areas of skin. The mechanism of action is not fully understood but several hypotheses [16] have been advanced:

(1) the increase in hydration; (2) the increase in temperature; (3) protection of the scar; (4) increased tension of O2; (5) action on the immune system. There is, currently, only one observational open label study, conducted on 57 patients. In the study, the gel was applied on the scars 2 times daily for 8 weeks with an average improvement in the thickness estimated between 40% and 50% compared to baseline. As regards the treatment of already formed hypertrophic scars, the gel should be applied in small amounts, twice daily for at least 8 weeks to achieve a satisfactory aesthetic result. Whereas for the purposes of prevention, the same dosage is recommended for at least 12–16 weeks; the treatment should be started as soon as possible after the risk of a patient developing hypertrophic acne scars has been identified. Treatment with silicone gel can be used in patients of any age and women of childbearing age. Moreover, the silicone gel can be used throughout the year, including summer [16].

1.5.1.9. Intralesional Steroid Therapy. Intralesional injection of steroids is one of the most common treatments for keloids and hypertrophic

scars. It can be used alone or as part of multiple therapeutic approaches. Corticosteroids may reduce the volume, thickness, and texture of scars, and they can relieve symptoms such as itching and discomfort. The mechanisms of action have not been completely clarified: in addition to their anti-inflammatory properties, it has been suggested that steroids exert a vasoconstrictor and an antimitotic activity. It is believed that steroids arrest pathological collagen production through two distinct mechanisms: the reduction of oxygen and nutrients to the scar with inhibition of the proliferation of keratinocytes and fibroblasts; the stimulation of digestion of collagen deposition through block of a collagenase-inhibitor, the alpha-2- macroglobulin. During the injection the syringe needle should be kept upright [14]. It is always preferable for the injections to be preceded by the application of anesthetic creams or be associated with injections of lidocaine. Intralesional steroid therapy may be preceded by a light cryotherapy with liquid nitrogen, 10–15 minutes before injection, to improve the dispersion of the drug in scar tissue and minimize the deposition in the subcutaneous and perilesional tissue. The steroid that is currently most frequently used in the treatment of hypertrophic scars and keloids is triamcinolone acetonide (10–40 mg/mL) [17].

1.5.1.10. Cryotherapy. Cryotherapy with liquid nitrogen can significantly improve the clinical appearance of hypertrophic scars and keloids and also determine their complete regression. The low temperatures reached during cryotherapy sessions cause a slowing of blood flow and cause the formation of intraluminal thrombus hesitant to anoxia and tissue necrosis. Age and size of the scar are important factors conditioning the outcome of this technique: younger and smaller scars are most responsive to cryotherapy. Compared with intralesional injections of corticosteroids, cryosurgery is significantly more effective than alternative methods for richly vascularized injuries 12 months younger [18].

1.5.1.11. Surgery. For the correction of large facial scars, W plasty seems to be optimal. This therapeutic procedure causes a disruption of the scar which makes the lesion less conspicuous. Especially in facial surgery, autologous skin transplants, namely, full thickness skin transplant or composite fat-skin graft, are another valuable alternative for achieving wound closure with minimal tension. The preferred donor sites for skin graft used for facial defects are the retro- and preauricular sites as well as the neck [18].

1.5.1.12. Subcision. Subcision is a minor surgical procedure used for treating depressed cutaneous scars and wrinkles. It is also called subcutaneous incisional surgery. Subcision is performed using a special hypodermic needle inserted through a puncture in the skin surface. The sharp edge of the needle is used to break fibrotic strands that are tethering the scar to the underlying tissue. The release of the fibrotic strands and new collagen deposition caused by wound healing leads to cosmetic improvement of the scar. Subcision can be safely performed in the outpatient setting and is usually well tolerated. The area to be treated is cleansed to remove dirt and make-up. The scar margins may be defined with a surgical marker, adjusting overhead lighting to delineate depressions. Local anesthetic is infiltrated. A tri-beveled needle (number 18 or 20 gauge) or a Nokor needle (fig.3) is inserted at an acute angle adjacent to the scar with the bevel upwards and parallel to the skin surface. Smaller gauge needles (25–27) may be used for small superficial scars and wrinkles. The needle is advanced through the dermis and moved back and forth in a fan-like motion. A snapping sound is heard as fibrous bands are transected in the deep dermis and deep dermal subcutaneous plane. The needle is rotated 90 degrees and moved again in a fan-like motion through the dermal scar (fanning subcision). The needle is removed and squeezed circumferentially around the exit point to prevent large hematoma

formation due to bleeding. Manual pressure is applied to the wound for several minutes [18].

1.5.1.13. Botox Injections. The appearance of the scar is reduced when Botox is injected into an area where muscle contractions pull on the acne scar. The Botox eases the tension and relaxes the area so that there is limited stress on the scar tissue and less visibility. However, Botox does not fill the scar and thus, a filler is needed for that. Only certain types of acne scars may benefit from this combination. Some surgeons already use Botox to prevent excess oil and sebum from developing in skin pores, so further research of the benefits of Botox to acne treatment came naturally to researchers [19].

1.5.2. Laser therapy of acne scar:-

All patients with box-car scars (superficial or deep) or rolling scars are candidates for laser treatment. Different types of laser, including the nonablative and ablative lasers are very useful in treating acne scars. Ablative lasers achieve removal of the damaged scar tissue through melting, evaporation, or vaporization. Carbon dioxide laser and Erbium YAG laser are the most commonly used ablative lasers for the treatment of acne scars. These abrade the surface and also help tighten the collagen fibers beneath. Nonablative lasers do not remove the tissue, but stimulate new collagen formation and cause tightening of the skin resulting in the scar being raised to the surface. Among the nonablative lasers the most commonly used are the NdYAG and Diode lasers. The ablative lasers are technologies with a high selectivity for water. Therefore, their action takes place mainly on the surface but the depth of action is certainly to be correlated to the intensity of the emitted energy and the diameter of the spot used. Among the ablative lasers, Erbium technologies are so selective for water that their action is almost exclusively ablative. CO2 lasers, which

present lower selectivity for water, besides causing ablation are also capable of determining a denaturation in the tissues surrounding the ablation and a thermal stimulus not coagulated for dermal protein. CO2 lasers have a double effect: they promote the wound healing process and arouse an amplified production of myofibroblasts and matrix proteins such as hyaluronic acid. Clinical and histopathologic studies have previously demonstrated the efficacy of CO2 laser resurfacing in the improvement of facial atrophic acne scars, with a 50%– 80% improvement typically seen. The differences in results reported with apparently similar laser techniques may be due to variations in the types of scar treated. Patients with a high skin type phototype are exposed to a higher risk of hyperpigmentation after treatment than patients with low phototype. All ablative lasers showed high risk of complications and side effects. Adverse reactions to ablative lasers can be classified into short-term (bacterial, herpetic or fungal infections) and long-term (persistent erythema, hyperpigmentation, scarring). In particular, scarring after CO2 laser therapy may be due to the over treatment of the areas (including excessive energy, density, or both), lack of technical aspects, infection, or idiopathic. It is necessary to take into account these aspects when sensitive areas such as the eyelids, upper neck, and especially the lower neck and chest are treated [20]. Nonablative skin remodeling systems have become increasingly popular for the treatment of facial rhytides and acne scars because they decrease the risk of side effects and the need for postoperative care.

Nonablative technology using long-pulse infrared (1.450nm diode, 1320 and 1064nm neodymium-doped yttrium aluminum garnet (Nd:YAG), and 1540nm erbium glass) was developed as a safe alternative to ablative technology for inducing a controlled thermal injury to the dermis, with subsequent neocollagenesis and remodeling of scarred skin. Although improvement was noted with these Nonablative lasers, the results obtained were not as impressive as the results from those using laser resurfacing. For

this reason, a new concept in skin laser therapy, called fractional photothermolysis, has been designed to create microscopic thermal wounds to achieve homogeneous thermal damage at a particular depth within the skin, a method that differs from chemical peeling and laser resurfacing. Prior studies using fractional photothermolysis have demonstrated its effectiveness in the treatment of acne scars with particular attention for dark skin to avoid post inflammatory hyperpigmentation. Newer modalities using the principles of fractional photothermolysis devices (FP) to create patterns of tiny microscopic wounds surrounded by undamaged tissues are new devices that are preferred for these treatments. These devices produce more modest results in many cases than traditional carbon dioxide lasers but have few side effects and short recovery periods [21]. Many fractional lasers are available with different types of source. A great deal of experience with nonablative 1550nm erbium doped fractional photothermolysis has shown that the system can be widely used for clinical purposes. An ablative 30WCO2 laser device uses ablative fractional resurfacing (AFR) and combines CO2 ablation with an FP system. By depositing a pixilated pattern of microscopic ablative wounds surrounded by healthy tissue in a manner similar to that of FP, AFR combines the increased efficacy of ablative techniques with the safety and reduced downtime associated with FP. Topographic analysis performed by some authors has shown that the depth of acneiform scars has quantifiable objective improvement ranging from 43% to 80% with a mean level of 66.8%. The different experiences of numerous authors in this field have shown that, by combining ablative technology with FP, AFR treatments constitute a safe and effective treatment modality for acneiform scarring. Compared to conventional ablative CO2 devices the side effects profile is greatly improved and, as with FP, rapid reepithelization from surrounding undamaged tissue is believed to be responsible for the comparatively rapid recovery and reduced downtime noted with AFR [22]. Pigmentation

abnormalities following laser treatment is always a concern. Alster and West reported 36% incidence of hyperpigmentation when using conventional CO2 resurfacing compared to a minority of patients treated with AFR treatments, probably linked to shortened period of recovery and posttreatment erythema[22]. The treatment strategy is linked to establishing the optimal energy, the interval between sessions, and a longer follow-up period to optimize treatment parameters.

On the other hand, *Pulsed Dye Laser* for hypertrophic scars and keloids was first proposed by Apfelberg et al. and Castro et al. in the 1980s and since then more lasers with various wavelengths have been introduced. Unfortunately, laser therapy for hypertrophic scars has had only variable success in the past due to the minimal improvement in a high percent of patients. On the contrary, the use of pulsed dye laser (PDL) has provided encouraging results in the treatment of hypertrophic/ keloidal scars over the past 10 years. Several studies have been conducted to investigate how the PDL works on hypertrophic/keloid scars. They have revealed that PDL decreases the number and proliferation of fibroblasts and collagen fibers appear looser and less coarse [23].Moreover, PDL also produces an increase in MMP-I3 (collagenese-3) activity and a decrease in collagen type III deposition. As a consequence, PDL flattens and decreases the volume of hypertrophic scars, improves texture, and increases elasticity, usually after two to three treatments. Additionally, pruritis and pain within the scars are significantly improved. Besides, no recurrence or worsening of PDL-treated scars occurs during the 4-year follow-up after cessation of treatment. The most common side effect of the PDL is purpura which can last as long as 7-10 days. Blistering can also occur as well as hypo- and hyperpigmentation which is more likely in darker skinned individuals. Therefore, the ideal candidates for PDL are patients with lighter skin types (Fitzpatrick Types I–III) because less melanin is present to compete with hemoglobin laser energy absorption [24].

1.6. Laser Basic Principles

The acronym laser shortly described the process that generates laser light [light amplification by stimulated emission of radiation]. In this process, photons are emitted and amplified by atoms and molecules within a special volume which is called the active medium, when excited by specific mechanism and the emitted photons pass between two mirrors one 100% refractive and the other is partially reflective through this path the amplification is obtained as the photon stimulate release another photons with the same energy and wavelength. All these events occur withen spetial structure called laser basic system as shown in figure (1-3) [25]

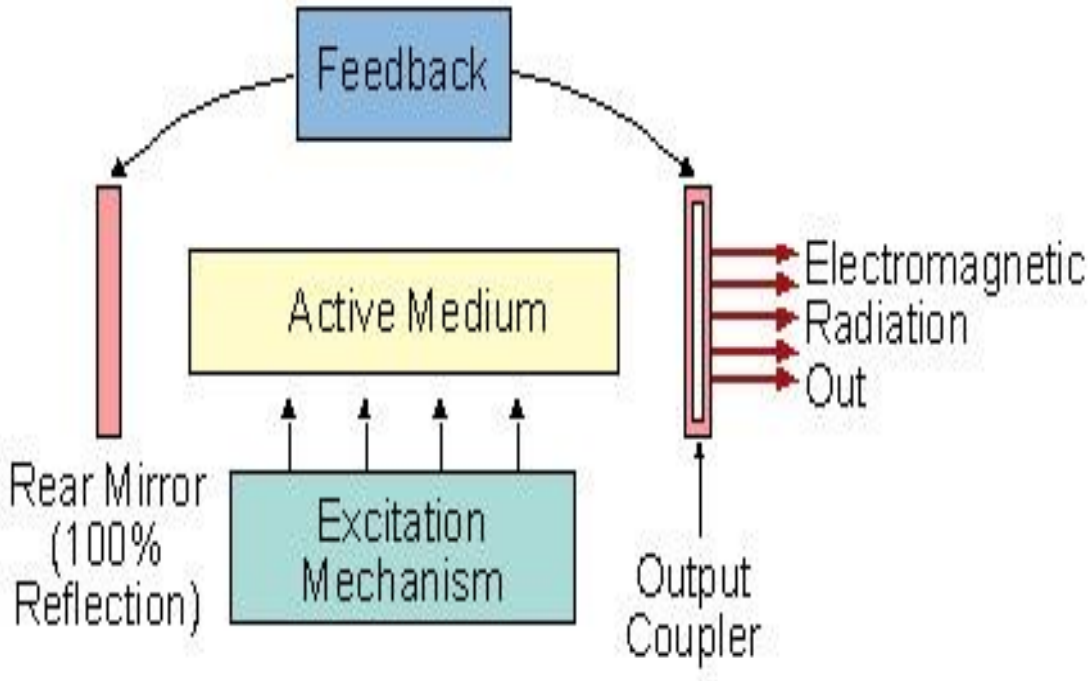


Figure (1-3) Various output modes of a conventional Laser [26]

1.6.1. Laser history:

Table (1-4) show a history of laser development (adapted from) [27]

Year, Contributors	Events
1917: Einstein, A.	Concept and theory of stimulated light emission
1948: Gabor, D.	Invention of holography
1951: Charles H Townes, Alexander Prokhorov, Nikolai G Basov, Joseph Weber	The invention of the MASER (Microwave Amplification of Stimulated Emission of Radiation) at Columbia University, Lebedev Laboratories, Moscow and University of Maryland.
1956: Bloembergen, N.	Solid-state maser- [Proposal for a new type of solid state maser] at Harvard University.
1958: Schawlow, A.L. and Townes, C.H.	Proposed the realization of masers for light and infrared at Columbia University.
1960: Maiman, T.H.	Realization of first working LASER based on Ruby at Hughes Research Laboratories.
1961: Javan, A., Bennet, W.R. and Herriot, D.R. -	First gas laser: Helium- Neon (He-Ne laser) at Bell Laboratories.
1961: Fox, A.G., Li, T.	Theory of optical resonators at Bell Laboratories.
1962: Hall, R.	First Semiconductor laser (Gallium-Arsenide laser) at General Electric Labs.
1962: McClung, F.J and Hellwarth, R.W.	Giant pulse generation / Q-Switching.
1962: Johnson, L.F., Boyd, G.D., Nassau, K and Sodden, R.R.	Continuous wave solid-state laser.
1964: Geusic, J.E., Markos, H.M., Van Uiteit, L.G.	Development of first working Nd:YAG LASER at Bell Labs.
1964: Patel, C.K.N.	Development of C02 LASER at Bell Labs.
1964: Bridges, W.	Development of Argon Ion LASER a Hughes Labs.
1965: Pimentel, G. and Kasper, J. V. V.	First chemical LASER at University of California, Berkley.

1965: Bloembergen, N.	Wave propagation in nonlinear media.
1966: Silfvast, W., Fowles, G. and Hopkins	First metal vapor LASER - Zn/Cd - at University of Utah.
1966: Walter, W.T., Solomon, N., Piltch, M and Gould, G	Metal vapor laser.
1966: Sorokin, P. and Lankard, J.	Demonstration of first Dye Laser action at IBM Labs.
1966: AVCO Research Laboratory, USA.	First Gas Dynamic Laser based on CO2
1970: Nikolai Basov's Group.	First Excimer LASER at Lebedev Labs, Moscow based on Xenon (Xe) only.
1974: Ewing, J.J. and Brau, C.	First rare gas halide excimer at Avco Everet Labs.
***1977: John M J Madey's Group**	First free electron laser at Stanford University.
1977: McDermott, W.E., Pehelkin, N.R,. Benard, D.J and Bousek, R.R.	Chemical Oxygen Iodine Laser (COIL).
1980: Geoffrey Pert's Group	First report of X-ray lasing action, Hull University, UK.
1984: Dennis Matthew's Group	First reported demonstration of a "laboratory" X-ray laser from Lawrence Livermore Labs.
1999: Herbelin,J.M., Henshaw, T.L., Rafferty, B.D., Anderson, B.T., Tate, R.F., Madden, T.J., Mankey II, G.C and Hager, G.D.	All Gas-Phase Chemical Iodine Laser (AGIL).
1999: Herbelin,J.M., Henshaw, T.L., Rafferty, B.D., Anderson, B.T., Tate, R.F., Madden, T.J., Mankey II, G.C and Hager, G.D.	All Gas-Phase Chemical Iodine Laser (AGIL).
2001: Lawrence Livermore National Laboratory	Solid State Heat Capacity Laser (SSHCL).

1.6.2. Properties of Laser light:

The Laser is not more than light but it is not an ordinary light. It represents an intense beam of light with particular properties.

Laser radiation emitted by Laser resonator, displays three important characteristics [28].

A- Coherent: i-e all the wave trains are in phase, in the time as well as in space figure (1-4)

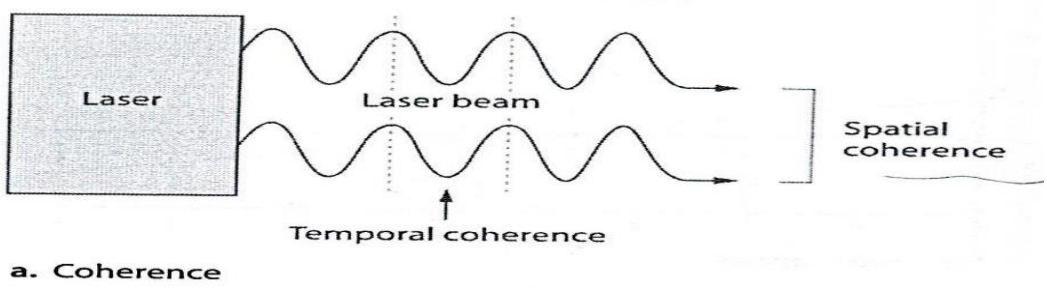


Figure (1-4) coherence of laser light

B- Collimated: The radiation is well collimated i.e the radiation beam is almost is parallel.

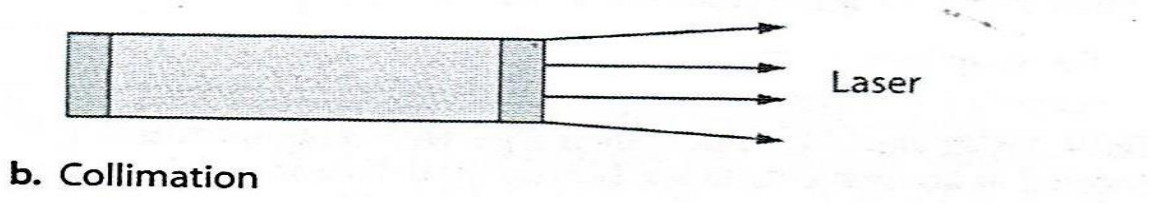


Figure (1-5) collimation of laser light

C- Monochromatic: The Laser radiation is monochromatic i-e all wave train have the same wave length, frequency and energy. Figure (1-6)

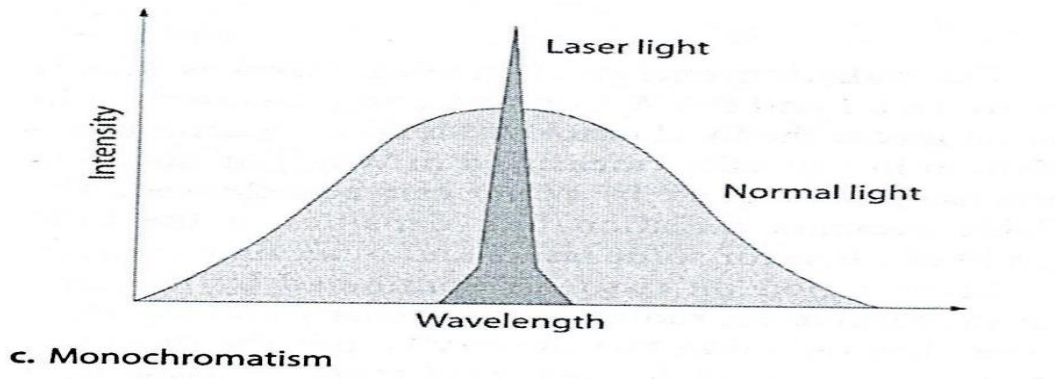


Figure (1-6) Monochromatism of laser light

In addition a Laser beam can achieve very high radiant power. These particular properties of Laser light in medical use allows selection tissue effects with precision not achieved by using traditional surgical instrument [28].

Each one of these characteristics may be achieved by other light sources, but the Laser is the only source of light combining all the above characteristics simultaneously [28].

1.6.3. Basic elements of laser

All lasers, regardless of size, shape, style, or application, have three main components [29].Figure (1-7).

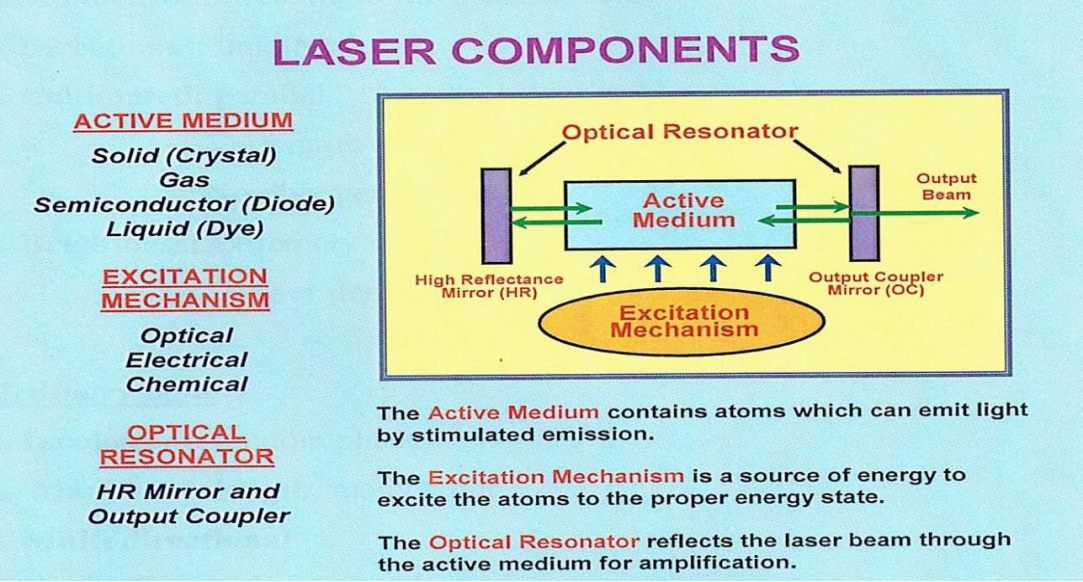


Figure (1-7) Laser Components [30].

1.6.3.1. Active medium.

The active medium is a collection of atoms, molecules or ions that absorb energy from an outside source and generate laser light by stimulated emission, the active medium can consist of a solid, liquid**,** gas or a semiconductor material [31].

• Solid state as Nd: YAG laser**.**

• Liquid as dye laser**.**

• Gas, as $C0_2$ gas laser.

• Semiconductor, as diode laser**.**

1.6.3.2. Excitation mechanism

Excitation mechanisms pump energy into the active medium by one or more of three basic methods; optical, electrical or chemical to create a population inversion. For a laser to create a "population inversion" where most or all of the particles are in the excited state, this is achieved by adding energy to the laser medium (usually from an electrical discharge or an optical source such as another laser or a flash lamp); this process is called pumping most common optical pumping by flash lamp, electrical pumping by electrical current, chemical reaction pumping, or the use of another laser light source [32].

1.6.3.3. Optical Resonator:

Reflect the laser beam through the active medium for amplification. It is consisting of:

- High Reflectance Mirror: A mirror which reflects 100% of the laser light.

- Partially Transmissive Mirror: A mirror which reflects less than 100% of the laser light and transmits the remainder.

The resonant cavity thus accounts for the directionality of the beam since only those photons that bounce back and forth between the mirrors lead to amplification of the stimulated emission. Once the beam escapes through the front mirror it continues as a well-directed laser beam. However, as the beam exits the laser it undergoes diffraction and does have some degree of spreading. Even more, the resonant cavity also accounts for the amplification of the light since the path through the laser medium is elongated by repeated passes back and forth. Typically this amplification grows exponentially. If the direction is parallel to the optical axis, the emitted photons travel back and forth in the optical cavity through the

lasing material between the totally reflecting mirror and the partially reflecting mirror. The light energy is amplified in this manner until sufficient energy is built up for a burst of laser light to be transmitted through the partially reflecting mirror; most lasers have three or more levels [32].

1.6.4. Classification of Laser:

Many classification:

1. According to the Active medium i-e (Gas, solid, liquid or a semiconductor).

2. According to the power i-e (Low power, intermediate power, high power).

3. According to the wave length (Ultraviolet, visible, Infrared).

4. According to the output (Continues, pulse wave Laser).

5. According to the Laser technique (Contact and noncontact) [33].

1.6.4.1.Type of Laser According to the Active Medium:

1. Solid state include: Nd: YAG Laser. Er: YAG Laser, Alexandrite Laser and Ruby Laser.

2. Gas state Laser: Carbone dioxide Laser, Argon ion Laser, and excimer Laser,

3. Liquid conductor.

4. Semiconductor.

While the diode and dye Laser is singular in their class[33].

1.6.4.2. According to the wave length:

Light represent one portion of much broader electromagnetic spectrum, and so the light can be divided into:

- UV 200-400nm

- Visible: 400nm – 700nm

- NIR "I" 755 -810nm

- NIR "II" 940nm -1064nm

- MIR 1.3 – 3mm

- Far IR 3mm and beyond [33].

1.6.5. Laser Device Terminology:

 Power: The rate of energy measured in watt "W".

Watt is one joule per second W = j\s

 Energy: Measured in joules (j)

 Irradiance or power density is the power delivered per unit area given w\cm2.

The power density: It is a critical parameter for it often determined the action mechanism in cutaneous application.

 Pulse width: Laser exposure duration called pulse width for pulsed Laser, is the time over which energy is delivered.

 Fluence: The amount of energy delivered. Per unit area some time called the "dose" or "radiant" exposure, given in j\cm?

 Spot size: Is Laser exposure spot size which greatly affects the beam strength inside the skin [26].

1.6.6. Laser beam modalities:

Laser may be divided into two broad groups.

1. Continuous wave (CW) laser.

2. Pulsed laser.

A CW laser is one whose power output undergoes little or no fluctuation with time. It exhibits a steady flow of coherent energy. Helium neon and argon gas lasers are typical examples, and are measured as power in watts**.** A larger group of lasers has output beams that undergo marked fluctuations i.e. beam power changes with time and said to operate in the "Pulsed mode".Nd:YAG solid crystal lasers and CO_2 gas lasers often, but not always, is operated in pulsed mode, and is expressed as energy in joules, & peak power = output energy / pulse duration [33].

1.6.7. Laser tissue interactions:

1.6.7.1. First: The effect of the tissue on the Laser light.

 Reflection: is defined as the returning of the electromagnetic radiation upon which it is incident. There are two types of reflections; the specular reflection, seen in smooth surfaces (mirrors) where the surface irregularity is small compared to the wave length of radiation. The other is the diffuse reflection where the roughness of the reflecting surface is comparable or even larger than the wavelength of the radiation [34].

 Scattering: is the basic origin of dispersion, her there is absorption and reemission. If the frequency of the wave is not corresponding to the natural frequency of the particles, scattering occurs. The resulting oscillation is determined by forced vibration. If the frequency of the wave equals the natural frequency of free vibration of a particle, resonance frequency occurs being accompanied by a considerable amount of absorption [34].

 Absorption is defined as the attenuation of the intensity of light when it passes through a medium. Factors affecting absorption are; the electronic constitution of the medium. the wave length of the radiation. the thickness of the absorbing layer. Internal parameters; the temperature and the concentration of the absorbing agents [34].

 Transmition light which pass through the tissue without any interactions between the photons of laser radiation and the tissue [this part constitute the basic principle of optical diagnostics] [34].

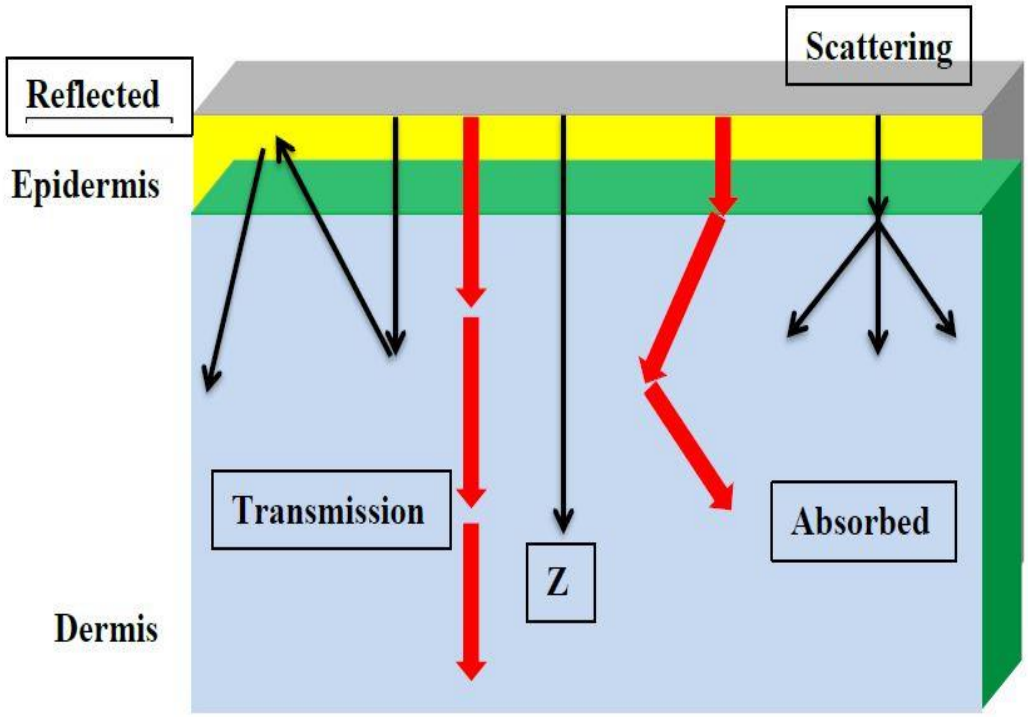


Figure (1-8) Pathway of light when it passes from one media to another [26]

1.4.7.2. Second: The effect of the Laser on the tissue:

Five categories of interaction types are classified today. These are photochemical interactions, thermal interactions, photoablation, plasma-induced ablation, and photodisruption. Each of these interaction mechanisms will be discussed in this chapter. In particular, the physical principles governing these interactions are reviewed. Emphasis is placed on microscopic mechanisms controlling various processes of laser energy conversion. Each type of interaction will be introduced by common macroscopic observations including typical experimental data and/or histology of tissue samples after laser exposure [34].

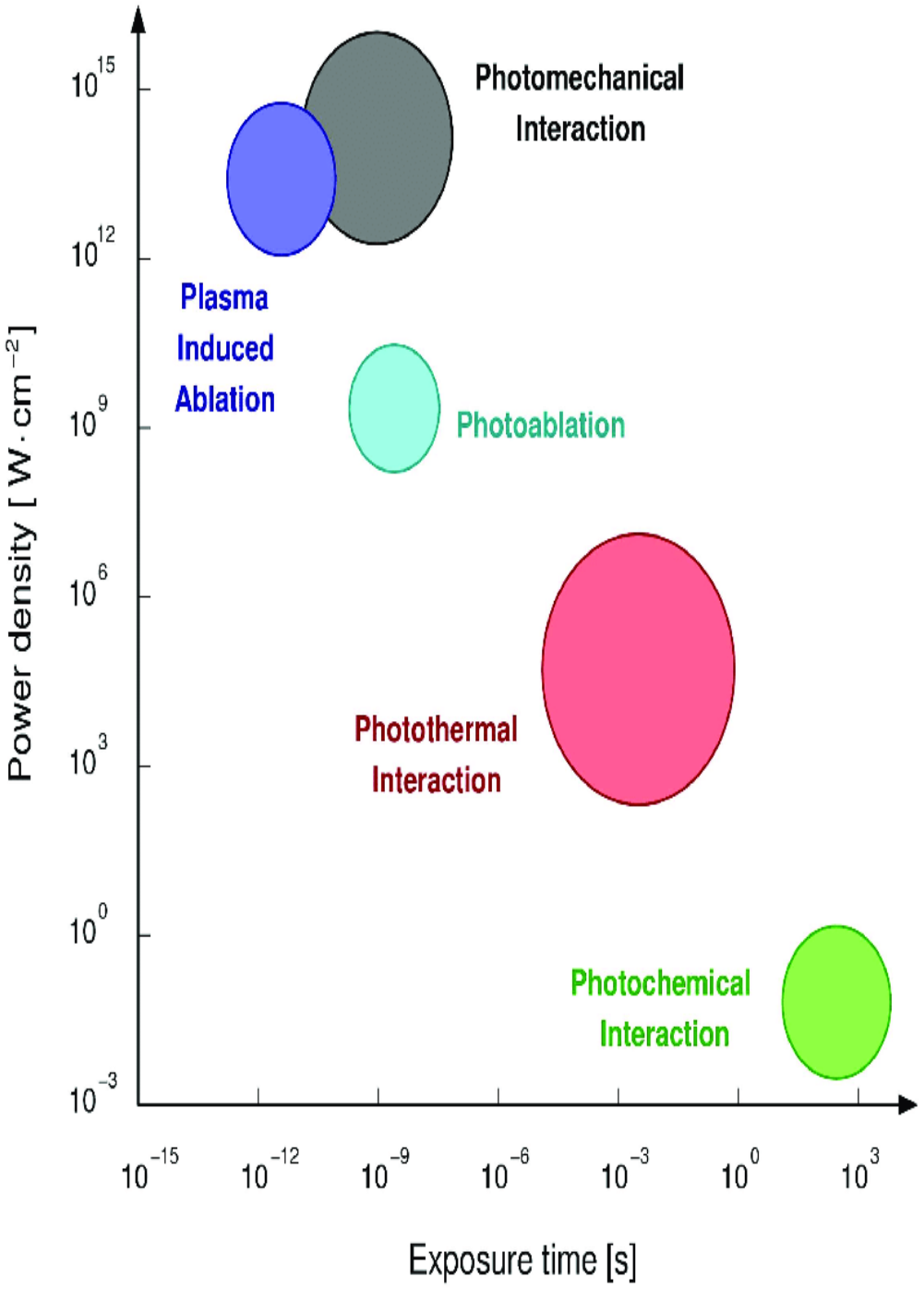


Figure (1-9) Five interaction mechanisms depend on the duration of the light exposure and the irradiance, i.e. the power per unit area, in W/cm2 [26].

1.6.8. Classification of laser tissue interaction:

Laser tissue interaction can be either:

1.6.8. A- Wavelength dependent interaction. Figure (1-10) [26]

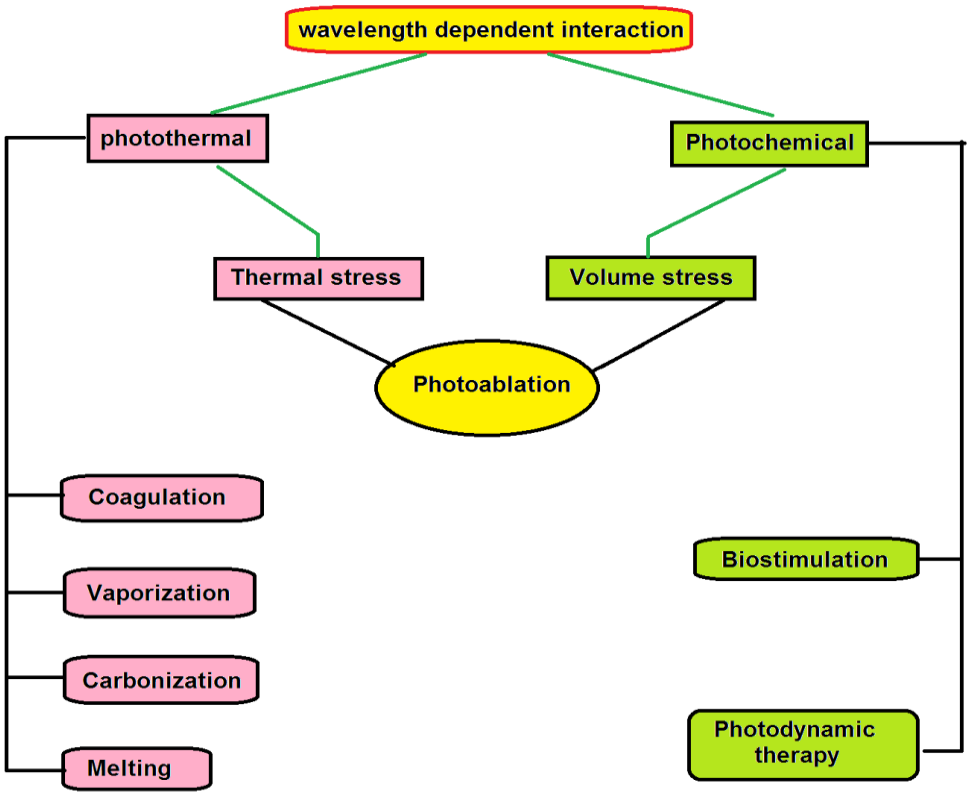
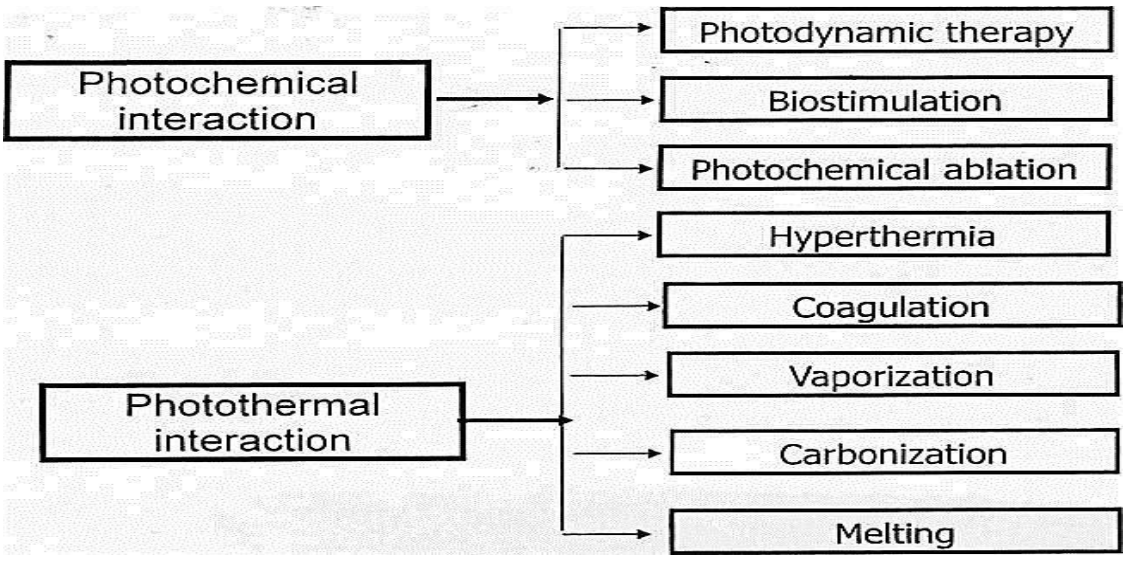


Figure (1-10) Wavelength dependent interaction

Table (1-5): Wavelength dependent interaction mechanism[26].



1.6.8.B. Wavelength Independent Interaction. Figure (1-11) [26]

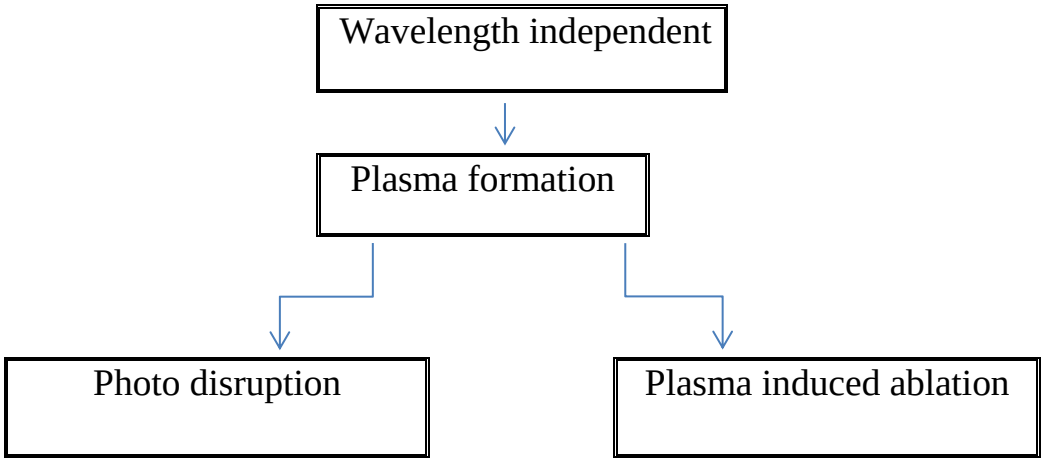


Figure (1-11) Wavelength Independent Interaction

1.6.8.A. Wavelength – Dependent Interactions:

Wavelength-dependent interactions of radiant energy depend largely on the laser wavelength that has impacted the tissue. Because the wavelength is a very important parameter that determines the index of refraction (governs the overall reflectivity of the target) as well as the absorption and scattering coefficients [34].

1.6.8.A.1. Photochemical Interaction:

Photochemical interactions take place at very low power densities (typically l W/cm2) and long exposure times ranging from seconds to continuous wave. Careful selection of laser parameters yields a radiation distribution inside the tissue that is determined by scattering. In most cases, wavelengths in the visible range are used because of their efficiency and their high optical penetration depths, photochemical interaction mechanisms play a significant role during biostimulation and photodynamic therapy (PDT).

Table (1-6): Summary of Photochemical Interaction [34].

Main idea	**using a photosensitizer acting as catalyst (only in photodynamic therapy)**
Observations	no macroscopic observations
Typical lasers	red dye lasers, diode lasers
Typical pulse durations	ls...CW
Typical power densities	0.01 ... 50W/cm2
Special applications	photodynamic therapy, biostimulation

1.6.8.A.2. Photodynamic therapy (PDT)

A chromophore compound called photosensitizer which is capable of causing light induced reaction in non-absorbing molecules when injected into the body and after the excitation by laser radiation the photosensitizer perform several simultaneous or sequential decays which result in intramolecular transfer reactions and at the end irreversible oxidation of cell structure result [34] .

1.6.8.A.3. photothermic interactions

The term thermal interaction stands for a large group of interaction types, where the increase in local temperature is the significant parameter change. Thermal effects can be induced by either CW or pulsed laser radiation. However, depending on the duration and peak value of the tissue temperature achieved, different effects like coagulation, vaporization, carbonization and melting may be distinguished. [34] Table (1-7)

Table (1-7) Thermal effects of laser [34].

Temperature	Biological effect
37° C	normal
45° C	hyperthermia
50° C	reduction in enzyme activity, cell immobility
60 °C	denaturation of proteins and collagen, coagulation
80° C	increased permeability of membrane
100°C	water vaporization, thermal decomposition (ablation)
>150°C	carbonization
>300 °C	melting

Since the critical temperature for cell necrosis is determined by the exposure time, no well-defined temperature can be declared which distinguishes reversible from irreversible effect. Thus exposure energy, exposure volume and exposure duration together determine the degree and extent of tissue damage.

The location and spatial extent of each thermal effect depend on the locally achieved temperature during and after laser exposure. [35]Figure (1-12)

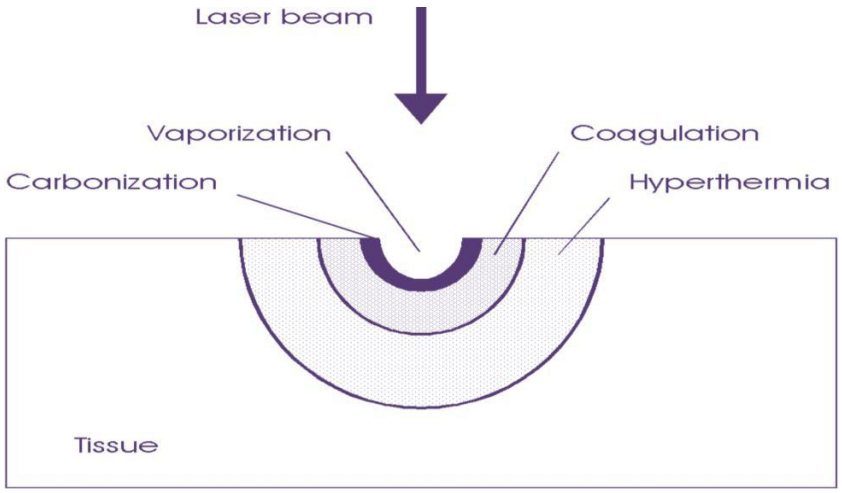


Figure (1-12) Location of thermal effects inside biological tissue. [34]

1.6.8.A.4. Flow chart for modeling thermal interactions:

Figure (1-13)

1) Heat generation is conversion of light to heat, which determined by laser parameters and optical tissue properties**.**

2) Heat transport is solely characterized by thermal tissue properties such as heat conductivity and heat capacity.

3) Heat effects**,** finally, depend on the type of tissue and the exposure time of temperature achieved inside the tissue (tissue reaction).

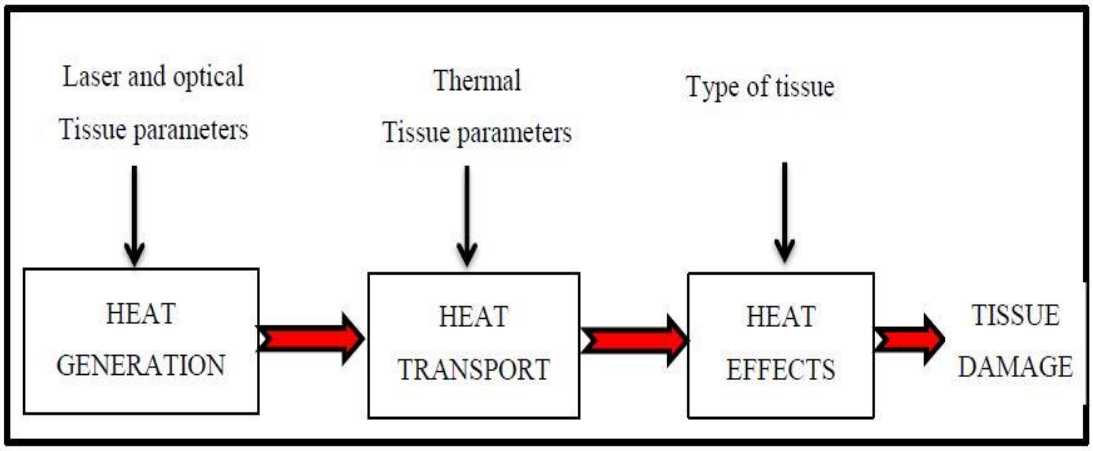


Figure (1-13): Flow chart of photothermic induction [34].

1.9.6. Effect of incident light on skin tissue:

"Photobiology"

Normally the percentage of incident light reflected from the skin surface is determined by the index of refraction. Difference between the skin surface (stratum corneum n = 1.55) and air n = 1 about 4-7% of light is typically reflected and is called Fresnel reflectance because it follow Fresnel's equation reflectance to the angle of incidence, plane of polarization, and refractive index [26] .

The angle between the light beam and skin determine the percentage of reflected light. More light is reflected at "grazing" angle of incidence. It

follows that to minimize surface losses, in most Laser application one should deliver light approximately perpendicular to the skin [26].

One can deliberately angle the beam. On the other hand, to decrease penetration depth and also attenuate the surface fluence by "spreading" the beam. On the other hand, the surface of skin reflects more light because of multiple-air interfaces. The light penetrate into the epidermis depend on wave length dependent absorption and scattering [26].

Because of scattering, much incident light is remitted (remittance refer to the total light returning to the environment due to multiple scattering in the epidermis, and dermis as well as from the reflection from the surface [26].

Tissue effect occurs only when light is absorbed. The absorption coefficient is defined as "probability per unit path length that a photon at a particular wavelength will be absorbed until it depends on the concentration of chromophores (absorbing molecule) present. The three primary skin chromophores are water, hemoglobin and melanin. The chromophore exhibit characteristic bands of absorption at certain wave, for example the melanin absorbe broadly across the visible and UV spectrum. The oxyhemoglobin and reduced hemoglobin in blood exhibit strong bands in UV, blue, green and yellow regions [26].

Water has strong absorption in infrared region. Optical properties of the epidermis and dermis are different. In pigmented epidermis, melanin absorption is usually the dominant process over the majority of optical spectrum (200-1000nm). In dermis there is strong wave length dependent scattering by collagen fiber which attenuate penetration of light. This scattering varies inversely with wave length [26].

The depth of penetration increase with wave length about 1300nm, penetration decrease due to absorption of light by water. The most deeply penetration wave length are within far UV and far IR regions [26].

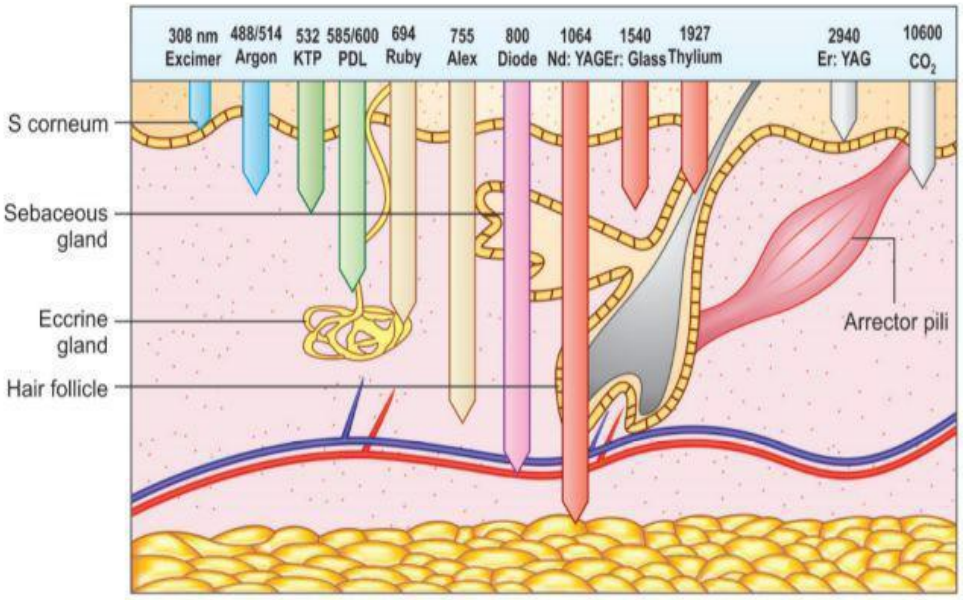


Figure (1-14) Optical penetration depth of common lasers [26].

1.7. Type of Laser used in this study:

Erbium: YAG Laser

Laser resurfacing of facial skin is a very popular method of rhytides and scar removal, in the 1990s; the high-energy, short-pulse carbon dioxide (CO2) laser became the most popular method utilized for these purposes. Multiple studies have been published describing multiple methods of treatment with different high-energy, short-pulse CO2 laser systems. Despite the dramatic results seen with high-energy, short-pulse CO2 laser resurfacing of facial skin, the enthusiasm for these systems has been diminished by the prolonged recovery time, the persistent erythema seen in many patients, and the limited safety margins leading to permanent side effects, even in the hands of experienced laser surgeons. The Erbium: YAG (Er: YAG) laser, with its 2940-nm wavelength, produces energy in the mid infrared invisible light spectrum. This wavelength has 10 -15 times greater water absorption than a CO2 laser at the 10,600-nm wavelength. The Er: YAG laser produces a pulse of 250-350 microseconds that is less than the thermal relaxation time of the skin, which is 1 millisecond. Also, the Er:

YAG laser causes tissue ablation with very little tissue vaporization and desiccation. The ablation threshold of the Er:YAG laser for human skin has been calculated at 1.6 J/cm2, as compared with 5 J/cm2,calculated for high-energy, short-pulse CO2 laser systems. Because the Er:YAG laser is so exquisitely absorbed by water, it causes l0-40 μm of tissue ablation and as little as 5 μm of thermal damage (depending on the parameters used). ln contrast, the high-energy, short-pulse CO2 lasers cause l00-120 μm of tissue damage, which is composed of 50-60 μm of apparent tissue desiccation (ablation or coagulation) and an additional 50-75 μm of thermal damage. Because of the predictable penetration of the Er:YAG laser, more passes are required to achieve an equal level of penetration into the dermis as compared with the high-energy, short-pulse CO2 laser systems. However, for this comparable level of tissue ablation, there is significantly less thermal damage. This allows for more precise control for tissue ablation and less residual thermal damage for Er: YAG laser. Unlike with the CO2 laser, for which color changes give a visual endpoint and a dermis devoid of water gradually prevents deeper resurfacing, there is no visual endpoint and no limit to the ablation depth of the dual-mode and variable-pulsed Er:YAG lasers. Therefore, the depth of successive ablative passes can be added together to determine total treatment depth [35].

1.8. Laser Safety:

Laser safety is safe design, use and implementation of lasers to minimize the risk .of laser accidents, especially those involving eye injuries Since even relatively small amounts of laser can lead to permanent eye injuries, the sale and usage of lasers is typically subject to government regulations, Moderate and high- power lasers are potentially hazardous because they can burn the retina of the eye, or even the skin. To control the risk of injury, various specifications, for example ANSI in the US and-IEC internationally, define "classes" of laser depending on their power and

wavelength. These regulations also prescribe required safety measures, such as labeling lasers with specific warnings, as shown in figure and wearing laser safety goggles when operating lasers [36].

1.8.1. Laser radiation hazards and damage mechanism

Laser radiation predominantly causes injury via thermal effects. Even moderately powered lasers can cause injury to the eye. High power lasers can also burn the skin. Some lasers are so powerful that even the diffuse reflection from a surface can be hazardous to the eye [36].

The Table (1-8) below summarizes the various medical conditions to the eyes caused by lasers at different wavelengths [36].

Table (1-8) Bio-effects on the eye

SPECTRUM	V • **EFFECT**	**UOCAUON**
UV-C (200-280 nm)	Photokeratitis	Cornea
UV-B (280-315 nm)	Photokeratitis	Cornea
UV-A (315-400 nm)	Cataract	Lens
Visible (400-780 nm)	Retinal injury*	Retina
IR-A (780-1400 nm)	Retinal bum, cataract	Retina, Lens
IR-B (1400-3000 nm)	Corneal bum, cataract	Cornea, Lens
IR-C (3000-1000000 nm)	Corneal bum	Cornea
* Retinal injury can be thermal, acoustic or photochemical.		

The skin is usually much less sensitive to laser light than the eye, but excessive exposure to ultraviolet light from any source (laser or non-laser) can cause short and long-term effects similar to sunburn, while visible and infrared wavelengths are mainly harmful due to thermal damage. Table (1-9) [37].

Table (1-9) Bio-effects on the skin

Spectrum	Location
UV-C (200-280 nm**)**	Erythema, cancer**,** accelerated aging
UV-B (280-315 nm)	Erythema, increased pigmentation, cancer, accelerated aging
UV-A (315-400 nm)	Erythema, increased pigmentation, skin burn
Visible (400-780 nm)	Photosensitive reactions, skin burn
IR-A (780-1400 nm)	Skin bum
IR-B (1400-3000 nm)	Skin bum
IR-C (3000-1000000 nm)	Skin bum

1.8.2. Maximum permissible exposure MPE

Is defined as the level of laser radiation to which a person may be exposed without hazard effect or adverse biological changes in the eye or skin, depending on the wavelength of the laser and exposure duration (exposure time). MPE is not a distinct line between safe and hazardous exposures. Instead they are general maximum levels to which various experts agree that MPE should be occupationally safe for repeated exposures.MPE depends on: [37]

- Wavelength
- Output Energy and Power
- Size of the Irradiated Area
- Duration of Exposure

1.8.3. Classification of Lasers hazards:

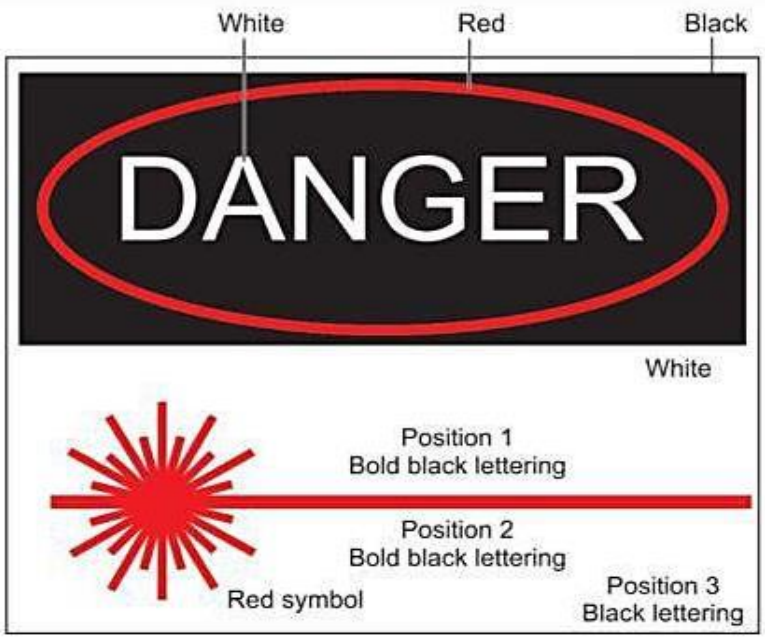
Table (1-10) Classification of Lasers hazards [26].

Class	Hazard	Warning statement
Class 1	Safe under reasonably foreseeable conditions (NOTE: Class 1 lasers include high-power that is fully enclosed, such that potentially hazardous radiation is not accessible during use).	
Class 1M	Safe for the naked eye, except if magnifying optics is used.	Do not stare directly with optical instruments.
Class 2	Safe for short exposures(less than 0.25s). The eye is protected by the blink reflex.	Do no stare into the beam.
Class 2M	Safe for shorts exposures(less than 0.25s). The eye is protected by the blink reflex except if magnifying optics is used.	Do not stare into beam or view directly with optical instruments.
Class 3R	Safe if handled with care, may be dangerous if mishandled. Risk is limited by the blink reflex and natural response to heating of cornea for infrared radiation.	Avoid direct eye exposure.
Class 3B	Direct viewing is hazardous. Protective eyewear necessary if the beam accessible. Safety interlocks are required to prevent access to hazardous laser radiation.	
Class 4	Can burn the skin and cause permanent eye damage. Class 4 lasers can also present a fire hazard. Safety interlocks with manual reset are required to prevent access to hazardous laser radiation.	Avoid eye or skin exposure to direct or scattered radiation.

1.8.4.1. Laser warning sign: Figure (1-15)

Warning sign shall be displayed on all doors entering the Laser treatment controlled area (LTCA) so as to warn those entering the area of Laser use.

Laser caution sign: CAUTION (Class II and some IIIR Lasers) [26].



Laser caution sign: DANGER (some Class IIIR, all Class III B and Class IV lasers)

1.8.4.2. Safety guides of Eye protection [36]

1. **Natural eye protection or defense:** when light strikes the eye, it stimulates the optical protective mechanism of the eye or what is called reflexes.

2. **Artificial or external eye protection:** by using protective eyewear that is designed for that specific wavelength and optical density .the selection of eyewear must be proper fit, comfort, and visual performance.

Figure (1-16) Protective eyewear

The use of eye protection when operating lasers of classes 3B and 4 in a manner that may result in eye exposure in excess of the MPE is required in the workplace by the U.S. Occupational Safety and Health Administration.

Protective eyewear (Figure 1-16) in the form of spectacles or goggles with appropriately filtering optics can protect the eyes from the reflected or scattered laser light with a hazardous beam power, as well as from direct exposure to a laser beam. Eyewear must be selected for the specific type of

laser, to block or attenuate in the appropriate wavelength range which have avisible beam, but it is more expensive, and IR-pumped green laser products do not always specify whether such extra protection is needed.

Eyewear is rated for optical density (OD), which is the base-10 logarithm of the attenuation factor by which the optical filter reduces beam power. For example, eyewear with OD3 will reduce the beam power in the specified wavelength range by a factor of 1,000. In addition to an optical density sufficient to reduce beam power to below the maximum permissible exposure laser eyewear used where direct beam exposure is possible should be able to withstand a direct hit front the laser beam without breaking [36].

1.8.4.3. Safety guides of Skin protection [38]

If lasers having the potential of causing skin damage are being used, adequate precautions should be taken to protect the skin, such as:

1. Protective clothing and face shields must be used.

2. Preoperative site should be protected by use of the least amount of power or energy required.

3. Avoid inflammable drapes as paper or plastics.

4. Avoid alcohol or must be dry before application.

5. Recommended cloth saturated with water around operative sites.

6. Wearing long sleeves and gloves made of appropriate fire-resistant material.

7. Laser resistant drapes for personnel.

1.9. Anesthesia used in laser:

Anesthesia for laser treatment must be appropriate for the particular therapy and ensure safety and minimum discomfort. Most dermatological procedures can be performed without any form of anesthesia [39].

1.9.1. Topical anesthesia:

The topical anesthesia is required for Laser use, EMLA (eutectic mixture of local anesthesia) is topical anesthesia with 2.5% lidocaine and 2.5% prilocaine cream was applied 30-60 minutes under closed dressing before initiating treatment to intact skin. 60 mints will anesthetize the skin to a level of 2.9 mm, while 120 mints provide a 4.5 mm depth of anesthesia [40].

1.9.2. Application of EMLA [26]

1. Patients can apply the topical anesthetic before arriving at the office, assuming they have proper instructions on its safe application.

2. Safe application entails gently washing the area to be treated with a mild cleanser and water.

3. Patients should avoid skin cleansing with benzoyl peroxide, which may decrease the topical anesthetic's absorption.

4. Patients may use a tongue depressor or gloved finger to apply a uniform layer of cream approximately 1/8"thick. If the product is applied with a bare finger, the anesthetic should be immediately washed off the digit once adequate application to the desired area occurs.

5. Depending upon the anesthetic used, the product is left in place for 30 to 60 minutes. Occlusion with plastic wrap or massaging the cream into the skin may achieve quicker onset of action, if necessary.

6. Immediately preceding the procedure, the material is removed with dry gauze, and the skin is wiped clean with water-dampened gauze. Complete removal of residual cream before laser procedures is particularly important.

7. It must be emphasized to the patient that improper product use can result in dire adverse events.

1.10. Literature of reviews

The efficacy and safety of fractional Er-YAG laser in treatment of atrophic acne scars were evaluated by Kirmal et al., who found it to be a highly effective and safe treatment modality for atrophic acne scars [41].

In their comparative study Khatri KA et al., showed that Erbium: YAG laser is an effective device for skin resurfacing and has faster recovery time and fewer side effects when compared to the CO2 laser resurfacing [42].

On the other hand, in their pilot study, Firooz et al. reported that fractional Er-YAG laser was an effective and minimally invasive method for treatment of atrophic acne scars [43].

1.11. Aim of Study

This study, was designed to evaluate the safety and effectiveness of fractional photothermolysis (fractionated Erbium: YAG laser 2940nm) in treating atrophic acne scars.

Chapter Two

Patients and Methods

2.1 Introduction

This study was done in private clinic in Baqubah city of Diyala Governorate- Iraq for the periods from 1st of June 2019 to 10th of October 2019. Ten patients with acne scars were selected for Er: YAG Laser treatment.

2.2. Patients and descriptions

The study enrolled 10 patients (7 females and 3 males) who seek facial acne scar treatment private clinic. Patients' age range from 20 years old to 50 years old with mean age of our patients was 28.9 years. Table (2-1) shows the distribution of the age groups; and figures (2-1) gender percentage.

Table (2-1) Distribution of the patient's age groups

Patients age group	No.	%
20 - 25	3	30
26 - 30	2	20
31 - 35	3	30
36 - 40	1	10
41 - 50	1	10
Total	10	100

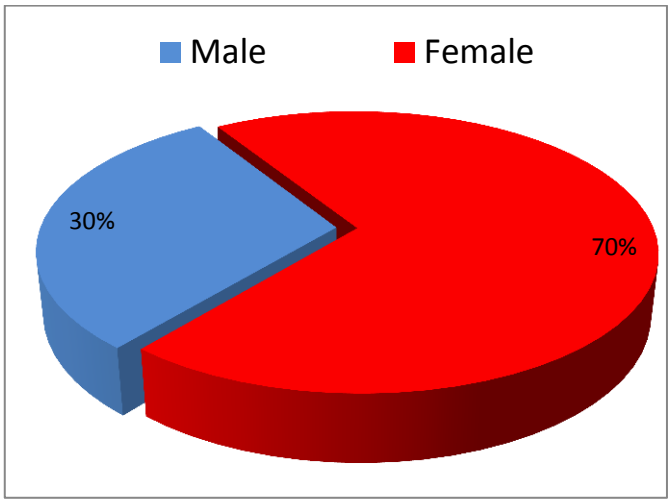


Figure (2.1) gender percentage

2.2.1. Inclusive criteria:

1- Patients should be 20-50 years of age.

2- Patients should have Fitzpatrick skin types of I-IV.

3- Patients should have at least mild acne scars.

2.2.2. Exclusive criteria:

1- The patient should not be receiving any additional systemic, topical, or intralesional treatment of the scars during the study.

2- Pregnant or lactating females.

3- Fitzpatrick skin type of V-VI.

4- A history of keloids or hypertrophic scars.

5- Photosensitivity.

6- Botulinum toxin injection, facial laser resurfacing, chemical peels, fillers, or usage of oral retinoid within the last 6 months.

7- Subjects with a known history of herpes simplex.

2.2.3. Ethical considerations

1- Research approval was taken from institute of Laser for post graduate studies/ University of Baghdad.

2- Written informed consent was taken from patient before being enrolled in the study.

2.3 Method

2.3.1. Data Collection

Data concerning patient history include Age, sex. As mentioned in table (2-1) and figure (2-1) previousely.

The preoperative evaluation included a complete history and physical exam, complete chemistry, blood counts. A thorough history of previous and current medications, especially isotretinoin, was obtained. History of previous wound healing, pigmentary problems and previous history of viral and bacterial infections were obtained.

2.3.2. Evaluation criteria

Therapeutic outcomes were assessed by standardized digital photography by the patient himself and by two blinded dermatologists. The dermatologists' evaluation and self-assessment level of improvement of the patients were evaluated using the following five-point scale:

0 = no change;

1 = slight improvement (0–25%);

2 = moderate improvement (26–50%);

3 = significant improvement (51–75%);

4 = excellent improvement (>75%).

As a simple, an easy, consistent, and reliable tool to assess the changes resulting from using rejuvenating procedures. In addition, the patients were asked to report any cutaneous or systemic side effects associated with laser treatment [44]

In particular, a pain scale of 0–3 was used to determine the level of discomfort during the procedures as following [44]:

0 = no pain

1 = mild pain

2 = moderate pain

3 = severe pain

Discussion with the patient is very important regarding what the surgery can accomplish and what the recovery period will entail and to be sure that the patient has nonrealistic expectations. The patients were informed about all risks that may be caused by the laser treatment and the pre- and post-operative care.

2.4. Laser System

The Er:YAG laser system 2940 nm (MCL30 Dermablate, Asclepion Laser Technologies, Germany) fig (2-2), has been used in this study and it's the following specifications (table 2-3) and physics (table 2-4).

Figure (2-2) Er: YAG laser system 2940 nm

Table (2-2) Er: YAG specifications

Specification	Laser
Laser model	Er:YAG laser (solid state laser)
Wavelength	2940 nm
Laser class	4
Required laser safety goggles (As specified in DIN EN 207: 2009)	OD4 DI LB4
Pulse duration	Microspot / Vario TEAM / VarioTEAM XL: 100/300/600/100 Steri-Spot: 300/600/1000 µs Romeo: 300 µs CUT: 300/600/1000 µs
Pulse energy	max. 2.5J
Pulse frequency	1/4/8/10/12/15/20 Hz
Spot sizes (handpieces)	VarioTEAM handpiece: 1/2/3/4/5/6 mm VarioTEAM XL handpiece: 8/10/12 mm MicroSpot Zoom handpiece: 13 ×13 mm 169 spots, diameter 350 - 600 µm 10 – 25% coverage

Table (2-3) Physics of the Erbium:YAG Laser

	Erbium:YAG
Wavelength	2940 nm
Threshold fluence	1.5 J/cm^2
Thermal relaxation	50 μsec
Thermal injury	5 to 10 μm
Tissue interaction	Ablation

Figure (2-3) Treatment parameter of Er: YAG Laser:

2.5. Technique

Prior to each treatment, the face was cleansed with a mild non-abrasive detergent and gauzes soaked in 70% isopropyl alcohol. Systemic antiviral therapy (acyclovir 400 mg twice daily) prescribed for each patient the night before operation as prophylaxis and for five days post operatively as well as topical antibiotics and a moisturizing cream, the patients were informed to apply a sunscreen for six weeks.

2.5.1.Topical anesthesia:

A topical anesthetic cream (EMLA, a eutectic mixture of local anesthesia of 2.5% lidocaine and 2.5% prilocaine) was applied under an occlusive dressing for 1 hour and subsequently washed off to obtain completely dry skin surface.

Figure (2-4): (Topical anesthesia)

2.5.2. Safety measure during the procedure:

In this study the laser employed was class IV laser. These types of laser can cause damage with direct intra beam exposure and from specular or diffuse reflections. So safety measures must be taken to provide protection from energy emissions of these lasers. All persons wear protective glasses appropriate to the procedure to eliminate the risk of eye damage. These glasses are designed with special wavelength and optical density for Er:YAG laser. The doctor goggles were transparent for Er: YAG Laser. (Figure 2.5).

In this research the eyes of the patient were covered with mops of cotton or gauze. The smoke and vapor plume were carefully extracted using a vacuum system, this is necessary to minimize the hazards to the patient and staff as many types of infections can be present in the vapor of Er:YAG laser. In this research the laser device put in isolated room & the patient enter to this room through an office room & the two rooms are separated by door which is closed during procedure of laser treatment.

A

B

Figure (2-5) protective eye wear A for patients, B for doctors

2.5.3. Photos

All patients were photographed before treatment with a digital camera (Sony DSC-T99 Cyber-shot® Digital Camera, 14.1 megapixel HD),and 1 week; 4weeks; 8 weeks; and 12weeks after procedure using identical camera settings, lighting, and patient positioning. All pictures were evaluated by two different blinded observers who had to determine the before and after pictures, and had to categorize the improvement using the five-point scale.

2.5.4. Laser therapy and parameters

Fractional Erbium: YAG laser 2940 nm wavelength was delivered to the whole face with a single pass treatment and with two passes for the acne scar areas with the following parameters:-

Hand piece	Fractional (13*13)mm
Mode	Fractional
Pulse energy (J/cm^2)	40
Multi shot	4X
Interval (sec)	Single(1.5s)
Pulse width (micro sec.)	300

The same parameters applied for all patients. Each patient was treated with a single session. Smoke evacuator and a forced air cooling accompanied the procedure to improve patients comfort and compliance.

After 24 hours, all patients were encouraged to apply topical antibiotic ointments twice daily, total sun avoidance was encouraged for 6 weeks. Patients were asked to return for the 1st visit 1 week after operation, when the reepithelialization occurred as determined by confluent erythema without erosion. After reepithelialization was observed, all patients were started on a tinted 60 SPF sun block and followed monthly for 3 months.

2.6. Statistical analysis

Statistical analysis has been done by using SPSS (statistical package for social sciences) version 17 establishing $P< 0.05$ as the lowest limit of significance. Paired *T*-tests were used to compare between the results before and after treatment

Chapter **Three**

Results and Discussion

This chapter presents the result, the discussion to explain these results, conclusion and suggestion. The result has been compared with other studies about treatment of acne scar with Laser.

3.1. Results

Below are the photographs of the patients under this study before and after Er:YAG acne scar skin resurfacing.

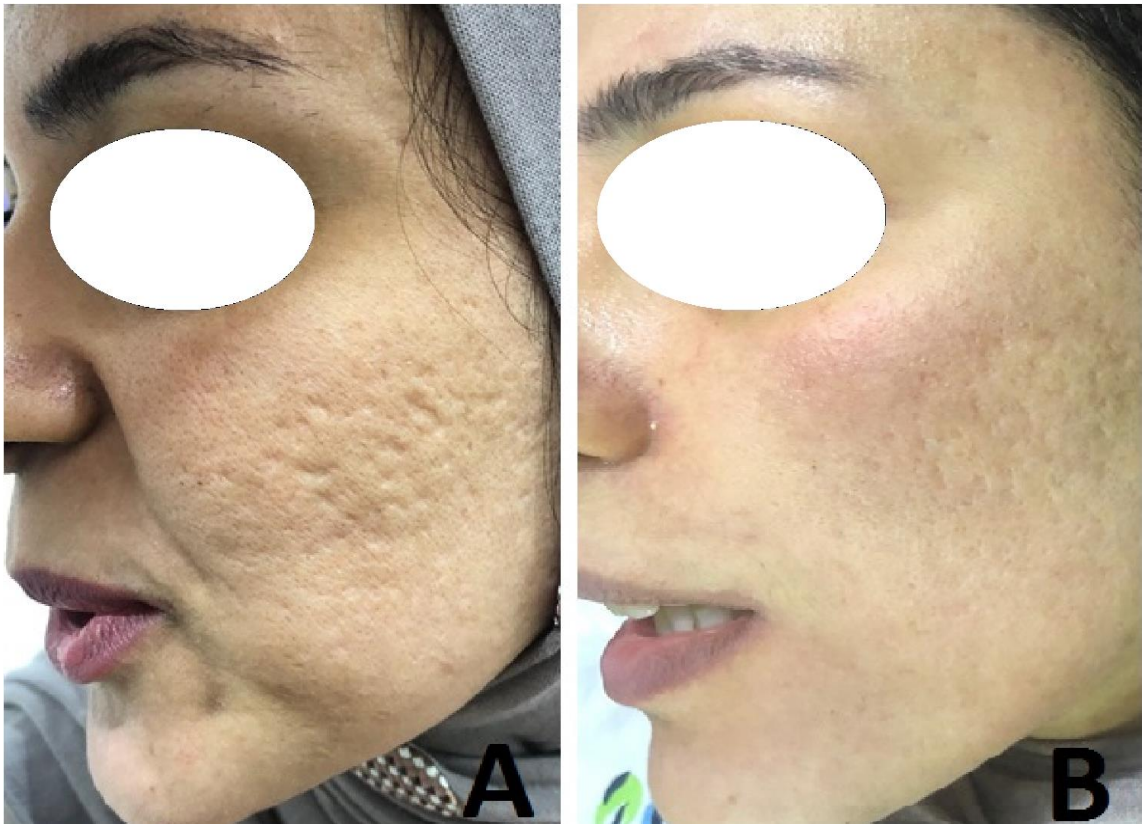


Fig. 3.1 Photos of patient 1 before (A) & After Treatment (B).

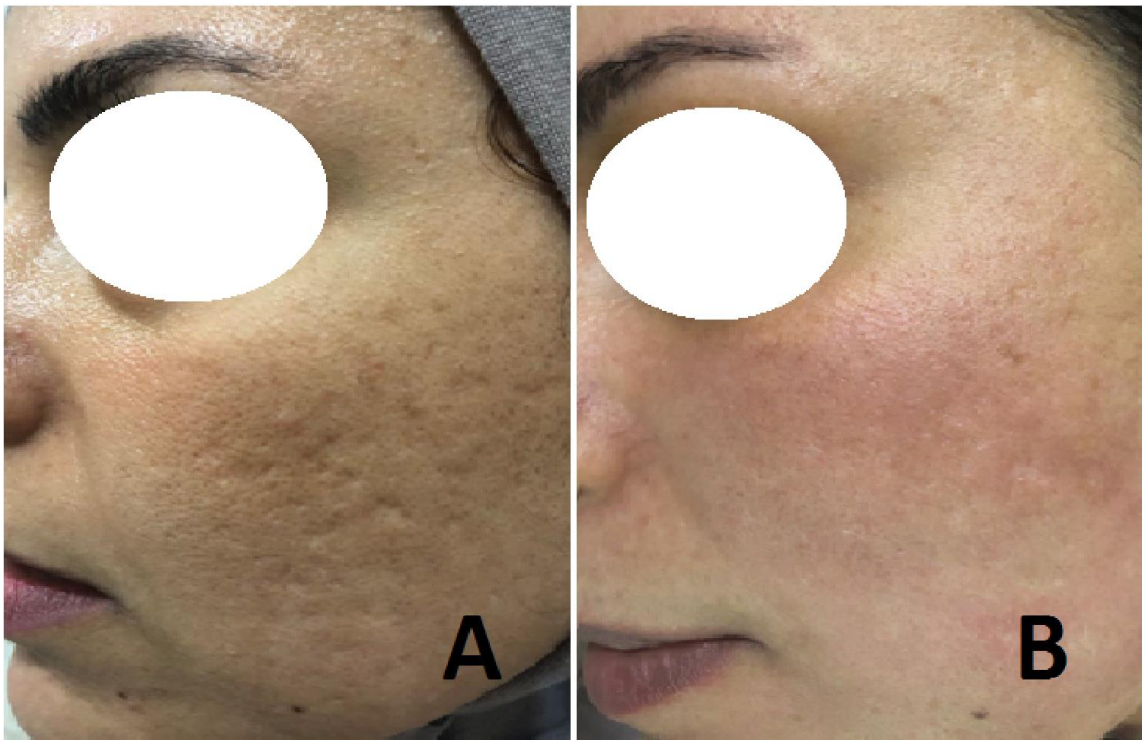


Fig 3.2 Photos of Patient 2 before (A) & After Treatment (B).

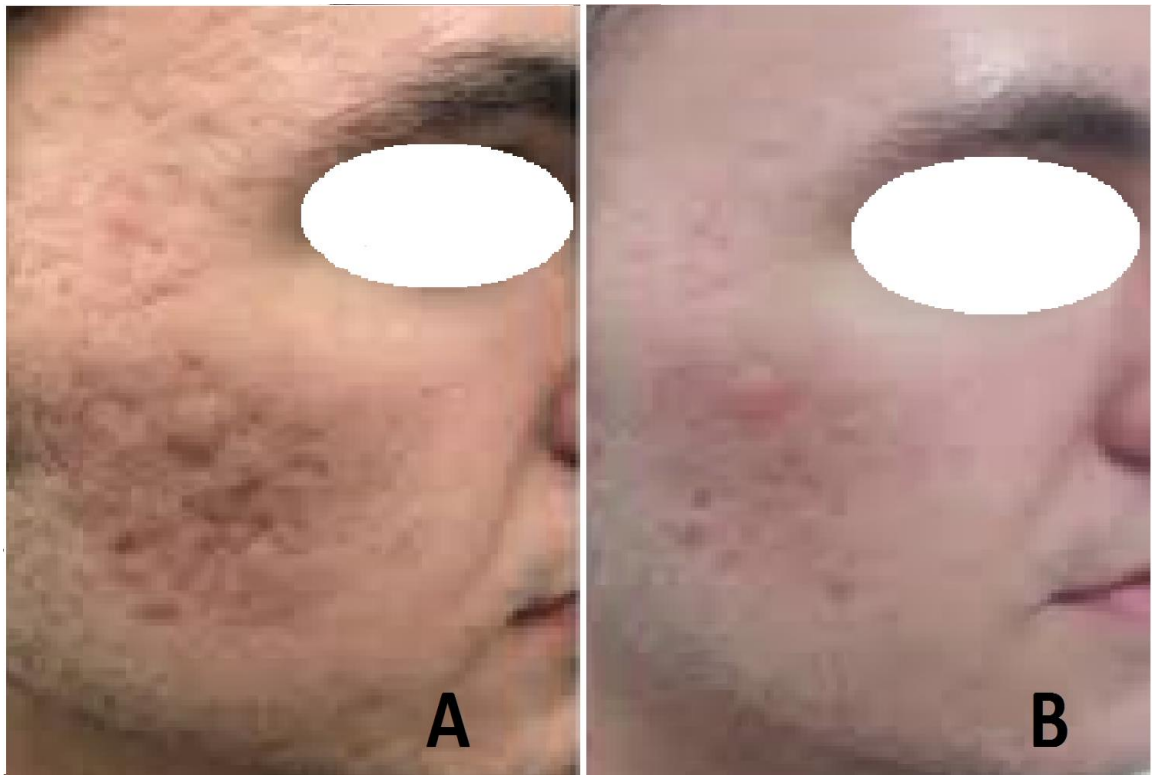


Fig. 3.3 Photos of patient 3 before (A) & After Treatment (B).

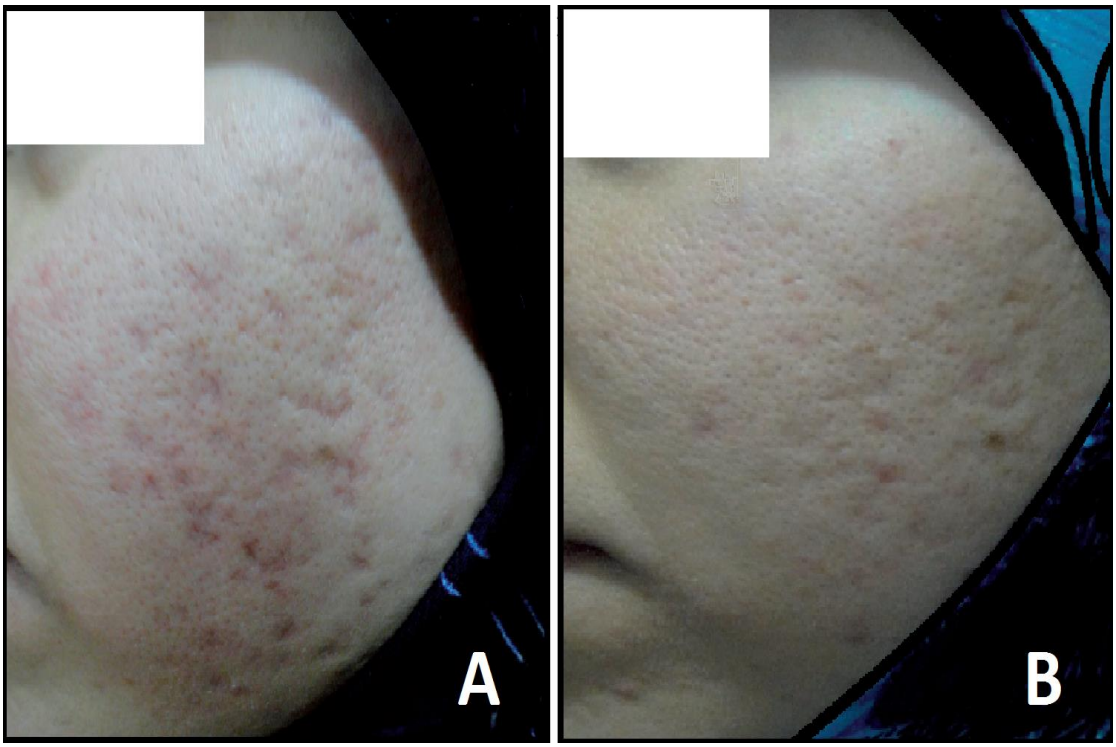


Fig. 3-4 Photos of patient 4 before (A) & After Treatment (B).

All patients had mixed types of atrophic acne scars, including ice pick, boxcar, and rolling scars, although, some particular type predominates and therefore is used to classify the patients accordingly (Table 3-1).

Table (3-1) show Patients predominant scars types

Patients Number	**Type of scar**
3 (30%)	significant rolling
4 (40%)	shallow boxcar
2 (20%)	Deep boxcar
1 (10%)	icepick scars

By using five-point scale mentioned previously in chapter two under the title evaluation criteria. Table (3-2) written after the evaluation by two different blinded observers were asked to perform two actions. First, to identify the photograph that showed better scar appearance. Second, to rate the difference in the severity of the acne scars using the above mentioned scale. To categorize the improvement using the scale, While table (3-3) represent patients estimation of the level of improvement.

Table 3-2 Response to treatment by Er: YAG laser for the level of improvement assessed by dermatologists

	Scores	0	1	2	3	4	**P Value**
Weeks	1 wk		3(30%)	3(30%)	3(30%)	1(10%)	0.002
	4 wk		2(20%)	3(30%)	4(40%)	1(10%)	
	8 wk		2(20%)	2(20%)	4(40%)	2(20%)	
	12 wk		1(10%)	1(10%)	5(50%)	3(30%)	

Table 3-3 Response to treatment by Er: YAG laser for the level of improvement assessed by the patient

	Scores	0	1	2	3	4	**P Value**
Weeks	1 wk		3(30%)	4(40%)	2(20%)	1(10%)	0.001
	4 wk		3(30%)	4(40%)	2(20%)	1(10%)	
	8 wk		2(20%)	3(30%)	3(30%)	2(20%)	
	12 wk		1(10%)	2(20%)	4(40%)	3(30%)	

Ten patients (7 females and 3 males) were included in this study. All patients completed the study, including the 3-months follow-up period. According to dermatologists' assessment (Table 3-2) the results were elevated dramatically from 10% in 1st week to 30% for excellent improvement after 3 months; although, this group is not the major group who shows improvement. Significant improvement group shows increase from 30% after 1 week to 50% after 3 months, it gives us a strong indicator of the overall results. The improvement scale was so obvious from first week (30% mild to 10% significant) through 4th – and 8th -week to become more satisfactory (10% mild to 30%) after three months of operation. The final results after 3 months were as follows: three patients (30%) reported excellent improvement, five patients (50%) significant improvement, one patient (10%) moderate improvement, and one patients (10%) mild improvement in the appearance of the acne scars, with a P-Value of about 0.002.

On the other hand, the patients' self-assessment of improvement was also remarkable and showed a great amount of satisfaction (Table 3-3). The results were rise obviously from 10% in 1st week to 30% for excellent improvement after 3 months; significant improvement group shows increase from 20% after 1 week to 40% after 3 months. The improvement scale was so obvious from first week (20% mild to 10% significant) through 4th – and 8th -week to become more satisfactory (10% mild to 30%) after 12 weeks of operation. The final results after 3 months were as follows: three patients (30%) reported excellent improvement, four patients (40%) significant improvement, two patients (20%) moderate improvement, and one patients (10%) mild improvement in the appearance of the acne scars with a P-Value of about 0.001. The results were almost comparable to the dermatologists' assessment.

Table (3-2) shows that the two factors (scores and weeks) are not independent, in another words there is a relationship between two factors. Similar conclusion can be reported for Table (3-3). The laser treatment was generally well tolerated.

All patients suffer from some degrees of pain from resurfacing table(3-4) the majority with moderate degree of pain 60%, while 30% express mild degree of pain and the minority 10% describe sever pain,

Table (3-4) Patients pain scale during operation

Degree of pain	Number of patients
0	0
1	3 (30%)
2	6 (60%)
3	1(10%)
Total	100%

The suspected adverse effects arise after Er: YAG laser skin resurfacing marked X as shown in table (3-5). All participants underwent

treatment-related pain to prevent any level of pain and discomfort of the patients, but there was no need for extra anesthesia. All participants reported mild erythema for approximately 2-3 days, and 80% of patients experienced edema for <24 hours following laser treatment this mostly due to inflammatory response to trauma. Peeling occurs from the second day and completed in the fifth day in 90% of the patients and in 10% last for 7 days. Social activity could commence as early as 3 days after the laser treatment and this one of the benefit of this type of treatments. Other possible adverse events related to laser treatment in general, such as pigmentary alterations (hyperpigmentation); bleeding; prolonged erythema; crust; scarring; and infection were not observed.

Table (3-5) adverse effects related to treatment by Fractional Er: YAG Laser

Adverse effects	Pt 1	Pt 2	Pt 3	Pt 4	Pt 5	Pt 6	Pt 7	Pt 8	Pt 9	Pt 10	%
treatment-related pain	X	X	X	X	X	X	X	X	X	X	100
mild erythema	X	X	X	X	X	X	X	X	X	X	100
Edema	X	X	O	X	O	X	X	X	X	X	80
Prolong Erythema	O	O	O	O	O	O	O	O	O	O	0
Severe peeling	O	O	O	O	O	O	O	O	O	O	0
Bleeding	O	O	O	O	O	O	O	O	O	O	0
Crust	O	O	O	O	O	O	O	O	O	O	0
Dermatitis	O	O	O	O	O	O	O	O	O	O	0
Hyperpigmentation	O	O	O	O	O	O	O	O	O	O	0
Hypopigmentation	O	O	O	O	O	O	O	O	O	O	0
Infection	O	O	O	O	O	O	O	O	O	O	0
Scaring	O	O	O	O	O	O	O	O	O	O	0

3.2. Discussion

Now day's rejuvenation of the skin is an important element of cosmetic surgery. This study done in Baqubah city- the capital of Diyala Governorate-Iraq, where a lot of people are of Fitzpatrick skin phenotypes I-IV. The aim of skin resurfacing is to remove damaged epidermis and upper dermis and to promote the formation of new, non- damaged epidermis and dermis and to resurfacing the skin by removing the shoulders of the skin scar and create a new smooth skin surface. The ideal method of skin resurfacing is one that can precisely remove abnormal epidermis and dermis and can accurately determine depth. Safety and reliability are also important criteria when comparing different techniques of skin remodeling.

The differences in treatment protocols as well as in the evaluation scales used to determine the severity of acne scarring in many clinical trials make it difficult to compare efficiency of the different fractional lasers existing for treatment of acne scars. Additionally studies that investigate the role of Erbium: YAG laser as a sole option in the treatment of atrophic acne scars are very limited.

Present study showed that mean age of studied patients was 28.9 years, which is the age when most of people seek for modern expression of an ancient desire to attain beauty and recapture a youthful appearance with predominance of female over male 70%to30% respectively due to the women anywhere more than men have the desire to attain beauty. These findings are close to results of Kutlubay et al. in a Turkish population [45]. which included 128 patients (53 male, 75 female) aged 22–42 years (mean age, 29.3) with atrophic facial acne scars with Er:YAG laser. At 3 months after the treatment, moderate to good clinical improvement was noted in most of the patients compared to baseline. Results were reported as excellent in 18 patients (14.1%), good in 67 patients (52.3%), moderate in

40 patients (31.3%) and minimal in three patients (2.3%).These findings look similar to our result which show 30% excellent improvement; 50% significant; 10% moderate and 10% slight improvement.

Results of Shakir J. Al-Saedy et al [46] study in Iraq included 40 patients which based on the same evaluation score of five-point scale that used in our study, they are reported that 25% of cases show excellent improvement; 50% significant improvement; 15% moderate improvement; and 10% slight improvement its very comparable to our results.

In a series of 78 patients, Weinstein [47] reported 70-90% improvement of acne scarring in the majority of patients treated with a modulated Er: YAG laser. He proposed that pitted acne scars may require ancillary procedures, such as subcision or punch excision, for optimal results. These procedures can be performed either prior to or concomitant with Er:YAG laser resurfacing this study is also comparable to our results.

Moustafa A. El-Taieb et al.[48] in Egypt made a study with 75 patients divided them into three groups; group A received platelet rich plasma ;group B treated with 2940nm Er:YAG laser; and group C had a combination of both PRP and Er:YAG laser ,patients treated with Er-YAG laser showed more marked improvement than those treated with PRP (P 0.001) but lower than combined therapy group, these results evaluated by two nontreating blinded physicians assessed the grade of improvement of skin smoothness by comparing photographs on a four-point scale as grade 4 ([75%) = excellent, grade 3 (51–75%) = marked, grade 2 (26–50%) = moderate, and grade 1 (0–25%) = minimal improvement. The results support The results of both assessment groups (the patients and the dermatologists) are significant as indicated by the *P* values which were 0.001 and 0.002 respectively in our study 9 patients show full satisfaction of the result, but 1 patient from the study that reported being unsatisfied with the results of this treatment method perhaps points to the cultural

expectation often observed in Iraqi patients of the need for complete cure, rather than recognition of improvement.

Conversely, Kwang Ho Yoo et al [49] determined in a previous study that all the patients indicated satisfaction with the results of their treatment and stated that they would undergo treatment again. This satisfaction indicated a great effect of the improvement of their facial appearance on their psyche, which was dramatically adversely affected prior to intervention.

Regarding the adverse effects or complication arise after Er: YAG laser skin resurfacing Elizabeth L. Tanzi, et al [50] study on 50 patients showed prolonged erythema6%, hyperpigmentation 40%, dermatitis 6%, infection 18%, hypopigmentation 0% and scarring 0%. In the recent study there were no any of these effects there are many explanation, may be due to good management; or low number of cases.

3.3. Conclusion:

1. Fractional Erbium:YAG 2940nm photothermolysis can be a safe and effective option for the treatment of acne scars in Iraqi patients by offering faster recovery time with no or mild side effect.

2. Fractional Erbium:YAG photothermolysis was associated with substantial improvement in the appearance of all types of acne scar, which includes the softening of scar contours as well as the reduction of scar depth.

3. Most patients began to show a visible improvement following only one session. According to visual assessments of patients and dermatologists, patients' improvement continues to occur even after 3 months of operation.

4. 90% of patient had good satisfy to the result.

5. The full clearance of the lesion is not obvious or we can say complete eradication of acne scars is not attainable, But there is very good improvement after treatment with Laser.

3.4. Recommendations:

We need further studies with:

1. Higher fluence and more passes.
2. More treatment sessions.
3. Further follow up for 6-12 months.

3.5. Suggestion:

In future and for more effective treatment of acne scar I suggest using combination of fractional ablative and non-ablative Er: YAG laser.

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الخلاصة:

الخلفية: حب الشباب مرض شائع بين الشباب ويستمر الى مرحلة البلوغ عند حوالي 12%-14% من الحالات مع عقد نفسية وإجتماعية شديدة . تقشير الجلد المجزء يمنح ميزة فريدة حيث يسمح بتقشير جزء من الجلد ويبقي الجزء الاخر طبيعي مما يسمح بشفاء الجلد بسرعة خلال يوم او يومين .

الهدف: هذه الدراسه اجريت لتقيّم درجة الامان وفعالية العلاج الضوئي المجزء بالليزر Er:YAG ,2940nm علاجا لآثار حب الشباب المضمحل.

طرق العلاج: سبعة نساء و ثلاثة رجال يعانون من حب الشباب المتوسط والشديد شاركوا في هذه الدراسة اللتي اجريت في العيادة الخاصة للامراض الجلدية والليزر في مدينة بعقوبة- محافظة ديالى- العراق خلال الفترة من الاول من حزيران الى العاشر من تشرين الاول. تمت معالجة الوجة بصورة كاملة بداية بضربة مفردة باستخدام ليزر Er:YAG, 2940 nm المجزء ثم اعيد علاج المناطق المصابة بأثار حب الشباب بمرحلة ثانية بضربة ثانية في نفس الجلسة نتائج العمل قيّمت باستخدام الصور الفوتوغرافية.

النتائج: ثلاث من المشاركين كانت نتائج علاجهم تحسن ممتاز, خمسة أخرين كانت نتائجهم تحسن جيد, وأحد الحالات نتائجها كانت تحسن متوسط و وأحد الحالات الاخرى كانت نتائج التحسن ضعيف في مظهر آثار حب الشباب.

الاستنتاج: ليزر Er:YAG المجزء آمن وفعال في علاج حب الشباب عند العراقيين ويمتاز بسرعة الشفاء و قلة الاعراض الجانبية مقارنة بطرق علاج حب الشباب التقليدية.

مفتاح الكلمات: حب الشباب, ليزر Er:YAG المجزء.

وزارة التعليم العالي والبحث العلمي
جامعة بغداد
معهد الليزر للدراسات العليا

معالجة حب الشباب في الوجه بإستخدام ليزر Er:YAG المجزء

دراسة مقدمة الى معهد الليزر للدراسات العليا / جامعة بغداد كجزء من متطلبات نيل شهادة الدبلوم العالي في تطبيقات الليزر في الطب / الجراحة التقويمية

إعداد
علي صادق طعمة
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