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Use of Fractional CO2 Laser in the Treatment of Xanthelasma Palpebrarum

A Dissertation

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بسم الله الرحمن الرحيم

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Dedication

To the woman who inspired me, my mother

To the man who taught me the meaning of struggle, my father

To my lovely wife and my children, my hope in life

To my good sisters

Ali

Abstract

Background: Xanthelasma palpebrarum is a yellowish sharply demarcated deposits of cholesterol underneath the skin, it usually occurs on or around the eyelids. Xanthelasma palpebrarum is a common cosmetic concern. Although there is a wide range of therapeutic modalities for it, there is no general consensus on the optimal treatment for such condition.

Aim: To evaluate the efficacy and safety of fractional carbon dioxide (CO2) laser in the treatment of xanthelasma palpebrarum.

Patients and methods: This therapeutic intervention study done at the laser unit clinic of the center of Dermatology and Venereology in the Medical City-Baghdad, during the period from October 2020 to February 2021. Included 10 adult patients (8 women and 2 men) with xanthelasma palpebrarum lesions were enrolled in this study, their ages ranged from 35-50 years old (mean= 43). The treatment was by either single session or up to 3 sessions of fractional CO2 laser (10,600 nm) with 2 to 4 weeks of intervals. All patients were assessed using digital photography and clinical observation.

Results: Xanthelasma palpebrarum lesions on both sides were successfully removed with significant improvement in size, color, and thickness. Short downtime and patient satisfaction was significantly excellent for lesions treated with fractional CO2 laser. No scarring and recurrence were reported during the study period.

Conclusion: Fractional CO2 laser is an effective and safe therapeutic option for patients with xanthelasma palpebrarum. Significantly short downtime, high patient satisfaction, few sessions, and mild complications.

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LIST OF ABBREVIATIONS

Abbreviations	**Item**
A	Area
AAPOX	Adult-onset asthma and periocular xanthogranuloma
AFR	Ablative fractional resurfacing
Arf laser	Argon fluoride laser
BCA	Bichloroacetic acid
Cm	Centimeter
CO2	Carbon dioxide
CPG	Computerized pattern generator
CW	Continuous wave
E	Energy
EMLA	Eutectic mixture of local anesthesia
Er:Yag	Erabium : Yag
FP	Fractional photothermolysis
fs	Femtosecond
GW	Gigawatt
h	Plank constant 6.626×10^{-34} joule/sec
HDL	High-density lipoprotein
Hz	Hertz
I	Irradiance
J	Joule

kW	Kilowatt
LASER	Light amplification by stimulated emission of radiation
LDL	Low density lipoprotein
MASER	microwave amplification by stimulated emission of radiation
µs	Microsecond
µW	Microwatt
mm	Millimeter
m W	Miliwatt
MTZs	Microthermal zones
Nd:YAG	Neodymium: Yttrium-Aluminum-Garnet
nm	Nanometer
OD	Optical density
P	Power
PDL	Pulsed dye laser
PDT	Photodynamic therapy
Ps	Picosecond
RF	Radiofrequency
sec.	Second
SP	Super pulse
T	Time
TCA	Trichloroacetic acid
UV	Ultraviolet

UP	Ultra pulse
XP	Xanthelasma Palpebrarum
ν	Frequency
W	Watt

Chapter one

Introduction &

Basic concepts

Chapter One
Introduction and Basic Concepts

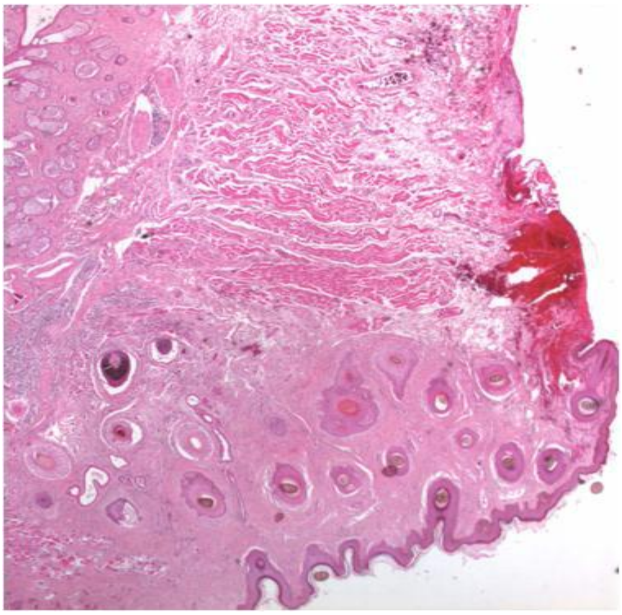
1.1 Introduction

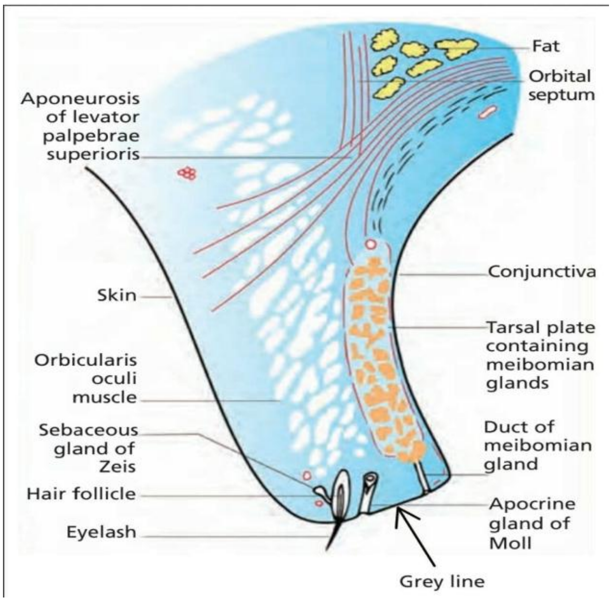
Xanthelasma palpebrarum is the most common type of the xanthomas characterized by asymptomatic usually symmetrical, soft, yellow, velvety polygonal macules, papules and plaques on or around the eyelids.[1] Xanthelasma palpebrarum is most commonly seen in middle-age and older women. It develops both in people with normal circulating lipid levels and in people affected by familial hypercholesterolemia, chronic cholestasis, and type III hyperlipoproteinemia.[2] It was suggested that it is caused by localized accumulation of lipid deposits by the movement of lipids from the blood vessels to the surrounding tissue, aggravated by factors such as increased heat, physical movement, and friction.[3]

Xanthelasmas are usually found on the inner canthi and have a tendency to be permanent, progressive, and coalescent.[4] There are numerous methods currently available for the management of xanthelasma. These include surgical excision, laser ablation using a variety of lasers (e.g., argon, carbon dioxide, Q-switched, and pulsed dye lasers), and chemical cauterization using trichloroacetic acid (TCA) or bichloroacetic acid (BCA), radiofrequency (RF) ablation and cryosurgery. However, each method of treatment is associated with particular limitations and side effects such as skin loss, scarring, recurrence, persistence, repeated treatments, expense, hypopigmentation, and hyperpigmentation.[5-9]

1.2 Anatomy of the Eyelids

The eyelids have distinct anatomical layers, (Figure-1.1a, b).





(A) (B)

Figure-1.1 Anatomy of eyelids:(A): Eyelid layers histology,(B): Eyelid layers cross-section

Each human eyelid is composed of six layers:

1) Epidermis

2 cell types:

A-Keratinocytes:

-Basal single row

-Squamous cell layer

-Granular layer

-Horny layer

B-Dendritic Cells:

-Clear cell melanocytes

-Langerhans cell

2) Dermis

3) Subcutaneous layer

4) Orbicularis oculi muscle

5) Tarsal plate

6) Conjunctiva

The grey line, an important anatomical landmark for surgical repair and pathological conditions of the lid margin such as blepharitis, divides the lid into an anterior lamella (skin and muscle) and a posterior lamella (tarsus and conjunctiva). The grey line represents the location of the marginal region of the orbicularis muscle (muscle of Riolan) seen through the lid skin. The skin is thin (The skin of eyelids is the thinnest of the body (<1 mm), and modified in several ways to protect the eyeball. It contains sebaceous glands associated with the fine hairs of the eyelashes (cilia) and both apocrine and eccrine sweat glands.

The tarsal plate of each eyelid gives the palpebral aperture shape and stability.

The eyelids are lined by a mucous membrane called the palpebral conjunctiva. The conjunctiva contains numerous goblet cells secreting mucin into the tear film.

The striated muscle of the levator palpebrae superioris opens the eye, and the striated orbicularis oculi muscle closes it. Both are innervated by the facial nerve. Two divisions of the trigeminal nerve supply sensation to the eyelids; the upper lid and medial canthus are supplied by the ophthalmic division and the remainder of the lower lid by the maxillary division.

The eyelid has a rich blood supply, mainly through the medial and lateral palpebral arteries, which are branches of the ophthalmic artery.

The blood drains through a network of veins to the facial and orbital veins and the cavernous sinus. Lymphatics drain the conjunctiva and tarsal plate to the post-tarsal plexus and the skin and orbicularis to the pretarsal plexus. The medial canthus and lower lid subsequently drain to the submandibular nodes whilst the lateral canthus and upper lid drain to the parotid and preauricular nodes.[10]

1.3 Xanthelasma Palpebrarum (XP)

The term xanthelasma is derived from the Greek xanthos (yellow) and elasma (beaten metal plate).[11]

1.3.1 Pathophysiology

Xanthelasma are a type of xanthoma appearing on the eyelids. Xanthomas are depositions of yellowish cholesterol-rich material that can appear anywhere in the body in various disease states. They are cutaneous manifestations of lipidosis in which lipids accumulate in foam cells within the skin. They are often associated with hyperlipidemias, of both primary and secondary types. Some occur with altered lipoprotein composition or structure, such as lowered high-density lipoprotein (HDL) levels. They frequently occur in patients with type II hyperlipidemia and in the type IV phenotype.[12] It was suggested that it is caused by the movement of lipids from the blood vessels to the surrounding tissue(leakage of plasma lipoproteins through dermal capillaries and phagocytosis by macrophages, creating lipid-laden foam cells, plays a role in xanthelasma pathogenesis.)[13] aggravated by factors such as increased heat, physical movement, and friction. Although elevation in the mean cholesterol or low-density lipoprotein cholesterol levels has been reported, xanthelasma palpebrarum can also be seen in patients with normal lipid levels. In the latter group, reduced high-density lipoprotein cholesterol and altered lipoprotein content or structure have been implicated. Hyperlipidemia is reported to occur in approximately 50% of patients with xanthelasma.[3]

1.3.2 Histopathology

Xanthelasma palpebrarum is composed of xanthoma cells or foam cells, which are histiocytes laden with intracellular fat deposits, these foam cells are typically found in the middle and superficial layers of the dermis in perivascular and periadnexal locations, with associated fibrosis and inflammation.[12] primarily located within the upper reticular dermis or in perivascular and periadnexal areas,. Intrahistiocytic vacuoles contain esterified cholesterol.[11]

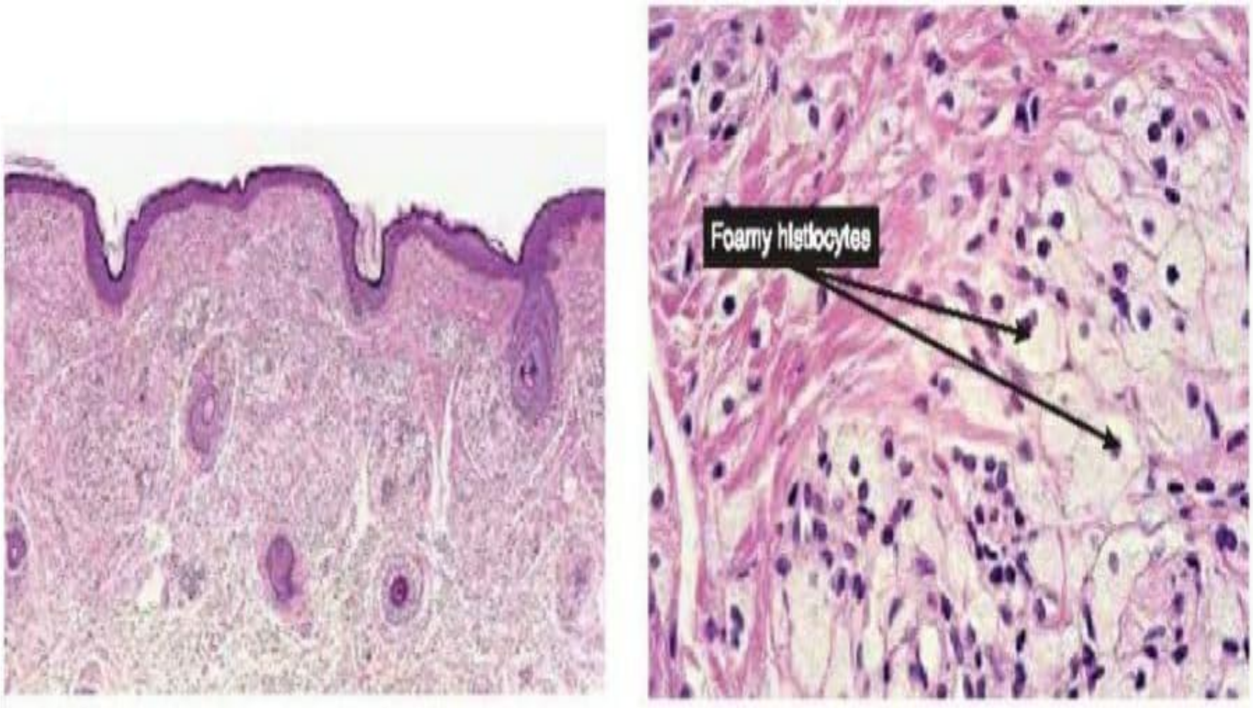


Fig.1.2.Histopathology of.Xanthelasma. (A) low power. Throughout the dermis there are poorly defined aggregates of pale staining cells.(B) high power. These foam ce1l& are seen throughout the dermis without an organized pattern. They have small nuclei and prominent vacuolated cytoplasm.

1.3.3 Epidemiology

Frequency

Xanthelasma palpebrarum is uncommon disease in the general population, Prevalence in the population is 4.4% with a prevalence of roughly 1.1% in women and 0.3% in men.[14]In United States Xanthelasma are not uncommon. With a variable incidence of 0.56%–1.5% in Western countries.[12]In India, the incidence of xanthelasma may range from 0.3%-1.5%. [1]

Mortality/Morbidity

These lesions have no premalignant potential; however, a study by Christoffersen et al finds that xanthelasmata can be a predictor of risk for myocardial infarction, ischemic heart disease, severe atherosclerosis, and death in the general population, independent of well-known cardiovascular risk factors (eg, plasma cholesterol, triglyceride concentrations). On the other hand, arcus senilis of the cornea has been found not to be an important independent predictor of risk.[14]

Sex

In case studies of patients with xanthomatosis, a predominance of xanthelasma in women has been seen; women, 32%, and men, 17.4%.[15]

Age

The age of onset ranges from 15-73 years, with a peak in the fourth and fifth decades.[15]

Prognosis

Recurrence is common. Patients need to be aware that studies completed after surgical excision showed recurrence in up to 40% of patients. This percentage is higher with secondary excisions. Of these failures, 26% occurred within the first year and were more likely to occur in patients with hyperlipidemia syndromes and in those with all 4 eyelids affected.

1.3.4 Clinical Presentation:

1.3.4.1 History:

Xanthelasma are the most common type of xanthoma. They often present in the absence of xanthomas elsewhere on the body, although, histologically, they are the same. They usually appear between ages 40 and 60.

Once plaques are established, they will remain static or increase in size. Patients generally present with concerns of their appearance, rather than symptoms of discomfort or inflammation.

1.3.4.2 Physical Examination:

Xanthelasma or xanthoma palpebrarum usually are located on the medial side of the upper eyelids. Clinically, it presents as yellowish papules, plaques, or nodules, and is soft in consistency, but can be semisolid or hard, vary from 2 to 30 mm in length. Lesions are usually symmetrically distributed on the medial side of the upper eyelids, but can also involve the lower eyelids. XP can be easily diagnosed on the basis of clinical background.[16]In cases which are ambiguous, surgical excision and histopathology should be undertaken. Lesions of XP have no premalignant potential. Generally, these lesions do not affect the function of the eyelids, but ptosis has been known to occur.

1.3.5 Causes:

Most individuals with xanthelasma have a lipid disorder. Many xanthelasma occur in normolipemic persons who may have low HDL cholesterol levels or other lipoprotein abnormalities. Eruptive xanthomas can be seen in primary and secondary causes of hyperlipidemia. Examples of primary genetic causes include familial dyslipoproteinemia, familial hypertriglyceridemia, and familial lipoprotein lipase deficiency. Early (childhood) onset of xanthelasma should suggest a hereditary lipid abnormality, especially familial hypercholesterolemia.

Secondary causes of hyperlipidemia include those related to various diets, drugs, disorders of metabolism, and some diseases. Diets rich in saturated fats and cholesterol, alcohol excess, and weight gain can cause severe but reversible hypercholesterolemia. Drugs that may cause altered lipid profiles include glucocorticoids, estrogens, anabolic steroids, some antihypertensive medications, retinoids, cyclosporine, cimetidine, certain antiepileptic drugs, and tamoxifen.[12] Hypothyroidism is the most common secondary cause of hyperlipidemia after dietary causes are considered. Uncontrolled diabetes is a common cause of secondary hyperlipidemia.

1.3.6 Differential Diagnosis:

Clinically, necrobiotic xanthogranuloma, syringomas, adult-onset asthma and periocular xanthogranuloma (AAPOX), palpebral sarcoidosis, and sebaceous hyperplasia are the main conditions to consider as differential diagnoses.

Atypical lesions of XP may have to be differentiated from Erdheim–Chester disease – a systemic xanthogranulomatous disorder (lesions are indurated) – and lipoid proteinosis (lesions appear as a string of nodules along the lid margin, plus other mucocutaneous involvement is present).[11] Retinal surgery with silicone oil in tissue was reported to mimic xanthelasma – an entity termed a pseudo-xanthelasma.[17]

1.3.7 Laboratory Studies:

Since more than 50% of patients with xanthelasma have lipid disorders, it is recommended that their plasma lipid levels are obtained, including low density lipoprotein(LDL) cholesterol and HDL cholesterol levels, triglyceride level, and apolipoprotein B100 level. Xanthelasma are usually an obvious clinical diagnosis, but, in rare cases, other lesions can simulate the appearance and may be associated with disorders of a more serious nature. If there is any doubt, surgical excision and pathologic analysis should be performed. Histologic Findings: xanthelasma are composed of xanthoma cells. These are foamy histiocytes laden with intracellular fat deposits primarily within the upper reticular dermis. The main lipid that is stored in hyperlipidemic and normolipidemic xanthelasmas is cholesterol. Most of this cholesterol is esterified.

1.3.8 Treatment & Management

Various treatment options are available for XP, but none of them produce satisfactory results.

1.3.8.1 Medical Management

Regular physical exercise and dietary fat restriction to less than 30% of total caloric intake in addition to lipid-lowering drugs, although important in the overall care of a patient with abnormal lipids, yield only limited response in the treatment of xanthelasma.

1.3.8.2 Surgical Treatment

Numerous surgical options are available for the removal of xanthelasma palpebrarum, including surgical excision, laser ablation, chemical cauterization, electrodessication, radiofrequency (RF) and cryosurgery. Complete removal of the lesions does not preclude the possibility that other new lesions will develop.

1.3.8.2.1 Surgical excision

For small linear lesions, excision is recommended, as scarring should blend in with the surrounding eyelid tissue. Smaller bulging lesions can be "uncapped" and removed; then, the flap can be replaced and sutured.[18]

In full-thickness excisions, the lower lid is more prone to prominent scarring, as the tissue tends to be thicker. Simple excision of larger lesions risks eyelid retraction, ectropion, or the need for more complicated reconstructive procedures. When xanthelasma removal has been incorporated into routine blepharoplasty, extending the incisional limits increases the risk for ectropion or webbing.[18]

1.3.8.2.2 Laser therapy

The first report of light for the treatment of XP was given by Meyer-Schwickerath.[19] He used xenon light in a procedure which was not simple but required several sittings. Laser ablation has been used to deliver targeted therapy in the treatment of XP.

Laser is an ideal therapy for XP. The mechanism of action is proposed to include (1) destruction of perivascular foam cells via thermal energy damage and (2) coagulation of dermal vessels leading to blockage of further lipid leakage into tissue, thus preventing recurrence.[19]

Precise photoablation and coagulation of the skin allow bloodless removal of lesions, with minimal scarring, pain, and perilesional inflammation; moreover, it reduces the risk of secondary infection. Various types of lasers have been tried, including carbon dioxide laser, Argon laser, Er: YAG laser, Q-switched Nd: YAG laser, and pulsed dye laser.[20] Energy is absorbed by skin chromophores and is then converted into heat, thus altering the foam cells, leading to resorption of lipoid material with adjacent thermal damage to the overlying epidermis.

Argon and pulsed dye lasers use shorter wavelengths of light preferentially absorbed by hemoglobin. With these physical characteristics, argon and pulsed dye lasers are used primarily for vascular lesions.[21] In the treatment of xanthelasma, these lasers may induce coagulation within the vessels of the upper dermis, thereby destroying the perivascular, lipid-laden foam cells and preventing further leakage of lipid into the surrounding tissue.[22] The 1450 nm diode, Nd:YAG, Er:YAG, and CO_2 lasers all use longer wavelengths of light absorbed best by cellular water. This allows for their use in skin resurfacing and the removal of epidermal lesions, with additional indications depending on the mode used (continuous, pulsed, etc.).[21] CO_2 lasers are considered the gold standard ablative laser. The beam is primarily absorbed by cellular water causing vaporization and ablation of tissue.[23] The ultra-pulsed variation allows for vaporization of a thin layer of tissue while allowing time for thermal relaxation of the surrounding tissue between pulses.[15] Similar to the CO_2 laser, the Er:YAG is maximally absorbed by water and causes vaporization of water within cells thereby ablating skin layer by layer.[24] Also with water as its chromophore, the 1450 nm diode laser has been shown to induce photothermal destruction of sebaceous glands in the mid-dermis by generating destructive heat at this particular depth.[25] This principle has led to its theoretical use in xanthelasma. Lastly, results of in vitro studies have shown the Q-switched Nd:YAG laser (1064 nm) to target subcutaneous fatty tissue containing predominantly triglycerides.[26,27] This ability to target fatty tissue allows for its possible use in targeting fat within xanthelasma.[28]

Carbon dioxide and argon lasers have been used with good results, but with risk of scarring and pigmentary changes. A high recurrence rate within the first 12–16 months was also seen with argon lasers. The carbon dioxide laser provides better hemostasis and, thus, is better suited for deeper lesions.

Er: YAG and Q-switched Nd: YAG lasers are reported to induce greater swelling, bleeding, and crusting and are also less efficacious.[28]Pulsed dye laser can be carried out without anesthesia, with excellent cosmetic results; however, it is effective inearly vascular lesions.

Complications of laser therapy include persistent erythema, superficial depigmentation, scars, severe burns, transitory or permanent lower lid ectropion, and corneal injuries or ocular perforation if the procedure is undertaken in the periocular region.

Advantages of lasers include better acceptance, avoidance of surgery, minimal tissue loss, good functional and cosmetic results, and therapy repeatability. Moreover, the procedure is easy to perform and gives fast results. Disadvantages include high cost and unpredictable results. In addition, it is not possible to obtain a histopathological specimen.

1.3.8.2.3 Radiofrequency

For XP, RF is considered to be an easy, safe, quick, inexpensive, and effective treatment. In RF procedures, thermal energy induces ionic agitation with vaporization at the cellular level in tissues. It uses a controlled RF current to reduce the tissue volume in a precise and controlled mode.

RF leads to fibrotic changes and volume reduction in tissues during the healing period.[29] The necrotic tissue in the lesions is gradually reabsorbed as part of the body's natural process, thus reducing the tissue volume. Cosmetic results are satisfactory.

1.3.8.2.4 Cryosurgery

Cryosurgery is one of the modern methods of treating XP. It is an outpatient procedure that is safe, relatively painless, effective, cosmetically acceptable, and free of any major complications. However, it requires multiple sessions, and post-inflammatory pigmentation can occur after the procedure.[11]

1.3.8.2.5 Chemical Cauterization

The use of chlorinated acetic acids has been found to be effective in the removal of xanthelasma. These agents precipitate and coagulate proteins and dissolve lipids. Monochloroacetic acid, dichloroacetic acid, and trichloroacetic acid (TCA) have been used with good results. Intralesional heparin sodium[30] and pingyangmycin[31] have been described for xanthelasma but are not yet conventional treatments.

TCA is an affordable and versatile treatment modality, particularly in the Indian setup. It is a short, simple, and inexpensive procedure. It has been observed that 100% TCA gives the best results in papulonodular lesions, 100% or 70% TCA give similar results in flat plaque xanthelasma, and, in macular lesions, 50% TCA is sufficient.[6] The technique requires the applicator to be rotated in a circular fashion with the greatest amount of TCA at the margin of the lesion, followed by neutralization with sodium bicarbonate. Hypopigmentation is the commonest side effect, followed by hyperpigmentation, irritation, and pain. Scarring and atrophy are other rare side effects. A Koebner-like phenomenon was also reported with TCA application.[6] Moreover, the depth of tissue penetration by the chemicals is hardly controllable; therefore, quite often, the therapeutic effect of chemical measures is unsatisfactory.[32]

1.3.9.2.6 Electrodesiccation

Electrodesiccation can destroy xanthelasmas when they are superficial but may require repeated treatments.[2]

1.3.9.3 Choice of treatment

If the patient has an underlying medical condition with abnormal lipid profile, the patient should be referred to an internal medicine specialist. If the patient is normolipidemic with no underlying medical condition, the lesion should be removed.

The modality to be used depends upon the size and location of the lesion. For lesions limited to the superficial dermis, of height ≤5 mm, soft in consistency, and onset ≤1 year, surgery is generally not required. In these cases, other modalities such as laser therapy, RF, TCA peel, and cryotherapy can be individualized depending upon the patient's need. For lesions involving the deep dermis and/or muscle, of height ≥5 mm, hard in consistency, and onset ≥1 year in addition to skin laxity, blepharochalasia, and need of aesthetic refinement, surgical excision is the most appropriate therapeutic option.[11]

1.4 Laser Basic Principles

The acronym **laser** shortly described **l**ight **a**mplification by **s**timulated **e**mission of **r**adiation.

1.4.1 Laser history:

The progress in laser therapies over the past three decades is built upon the foundation of Albert Einstein's The Quantum Theory of Light. In 1917 Einstein proposed, amongst other concepts, that light consists of quanta of energy, and he hinted at the notion of amplification. In 1958, Townes and Schawlow described Microwave Amplification by Stimulated Emission of Radiation (MASER). This was further refined by Thomas Maiman as Light Amplification by Stimulated Emission of Radiation (LASER). A few years after development of lasers in 1960, physicians such as Leon Goldman started to apply this new and exciting radiation in dermatology. Since 1963, numerous physicians have investigated the use of various types of lasers to treat different skin disorders[33]. Early laser devices, however, were functionally limited by their lack of selectivity. In the early 1980s Anderson and Parrish developed the concept of selective photothermolysis, in which heterogeneity of the skin allows for selective injury in microscopic targets[34]. Lasers that vaporize a thin layer or column of tissue have also been developed. The concept of fractional photothermolysis (FP), reported by Manstein and colleagues in 2004, recently launched another era of lasers in dermatology, in which patterns of very small non-selective thermal damage zones are used to stimulate skin remodeling without scarring.[35]

1.4.2 Laser components

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 semi- conductor material. [(36)]

- Solid state as Nd: YAG laser.
- Liquid as dye laser.
- Gas, as CO_2 gas laser.
- Semiconductor, diode laser.

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. [36]

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 and 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.[36]

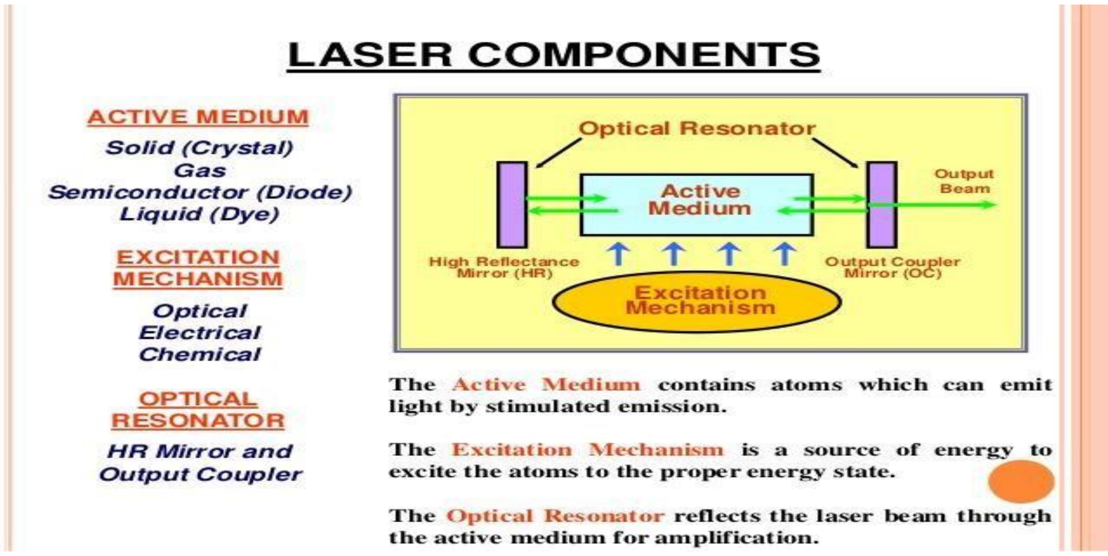


Figure 1.3 Laser Components

1.4.3 Properties of Laser Light

Unlike ordinary light, laser light is coherent, collimated, monochromatic, directionality. [36]

1-Coherent: refers to synchronized phase of light waves, where all individual waves are in step or ‘in –phase,’ with one another at every point. So coherence” is the term used to describe the in – phase property of light waves within a beam (Figure 1-4)

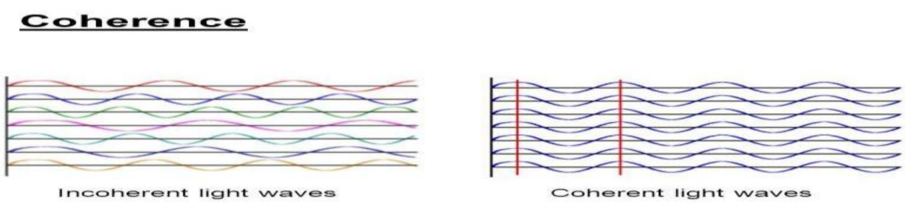


Figure (1.4) Incoherent Light and Coherent Light

2-Monochromatic: refers to single wavelength (color) of a laser beam. Ordinary white light is a mixture of colors, as can be demonstrated by passing ordinary light through a prism, will be dispersed into its components wavelengths (colors).

3-Collimated: refers to the parallel nature of the laser beam, it is emitted in a very thin beam, with all light rays parallel. By focusing and defocusing this beam, a surgeon can vary its effects on tissue.

4-Directionality: divergence of beam is very small as shown in (Figure1.5).

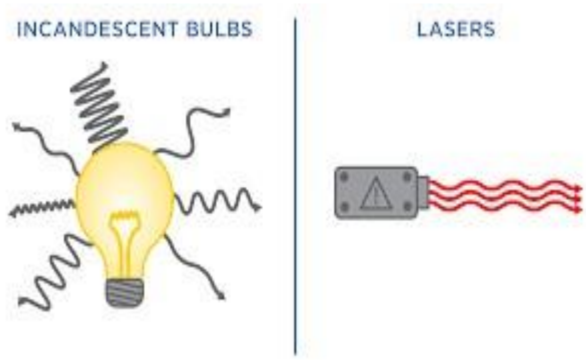


Figure (1.5) Difference between Light Bulb & Laser and its Directionality.

5- Brightness: refers to the wave that contains a lot of energy. These properties allow a laser of a given power to be immensely more powerful than ordinary light of the same power.

These unique characteristics make the laser useful for thousands of applications including medical applications.

1.4.4 Laser Beam Modalities:

1. Continuous wave (CW) laser.

2. Pulsed laser.

3. Chopped 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.[36]

1.4.5 Laser parameters

- Wavelength (nm) is an important laser parameter. It determines how deep laser radiation penetrates into tissue, i.e. how effectively it is absorbed and scattered. [37]
- Power(W): The rate at which the energy is delivered (W) [36]
- Exposure time(S):The duration of exposure to laser(s). primarily characterizes the type of interaction with biological tissue.[37]
- Energy(J)= P x t,(j) [36]
- Spot size (cm). [36]
- Power Density (Irradiance)=P/A (W/cm^2). [37]
- Energy density (Fluency)= E/A(J/cm^2) , its value only serves as a necessary condition for the occurrence of a certain effect and then determines its extent. all medically relevant effects are achieved at energy densities between 1 J/cm^2 and 1000 J/cm^2 [37]
- PRR is the pulse repetition rate, which represent number of pulses per second. [36]

Selective Photothermolysis

Selective, localized heating (with focal destruction of "target" structures) is achieved by a combination of selective light absorption and pulse duration shorter than or approximately equal to the TRT of the targets. Choice of wavelength(s) must correspond to absorption by chromophores within the skin targets. The wavelength must also penetrate to the anatomic depth of the skin targets. The theory of selective photothermolysis really only applies to pulsed laser systems, as continuous laser results in bulk heating of tissue, and hence little (selectivity).[38]

1.4.6 Laser Tissue Interactions

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, and diffuse reflection. [37]4–7% of light is typically reflected because of the difference in the refractive index between air (n = 0) and stratum corneum (n = 1.45).

***Scattering:** Scattering occurs when photons "bounce" off particles and fibers within the skin, leading to diffusion of the incoming beam of light and limiting its depth of penetration. Increasing wavelength, photons are less deflected on their path into skin. Thus, the longer the wavelength, the higher is the penetration depth of radiation in skin[37]

***Absorption:** is defined as the attenuation of the intensity of light when it passes through a medium. Factors affecting absorption are: (1) The electronic constitution of the medium. (2) The wave length of the radiation. (3) The thickness of the absorbing layer. (4) Internal parameters; the temperature and the concentration of the absorbing agents. [37]

***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]. The previous mentioned effects are shown in figure (1.6).

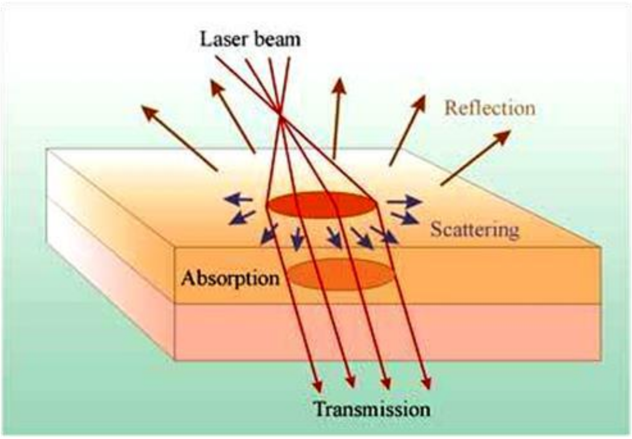


Figure (1.6) Pathway of light when it passes from one media to another

The Effect of the Laser on the Tissue

Five categories of interaction types are classified today. These are photochemical interactions, thermal interactions, photoablation, plasmainduced ablation, and photodisruption. 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. [37] The previous mentioned effects are shown in figure (1.7).

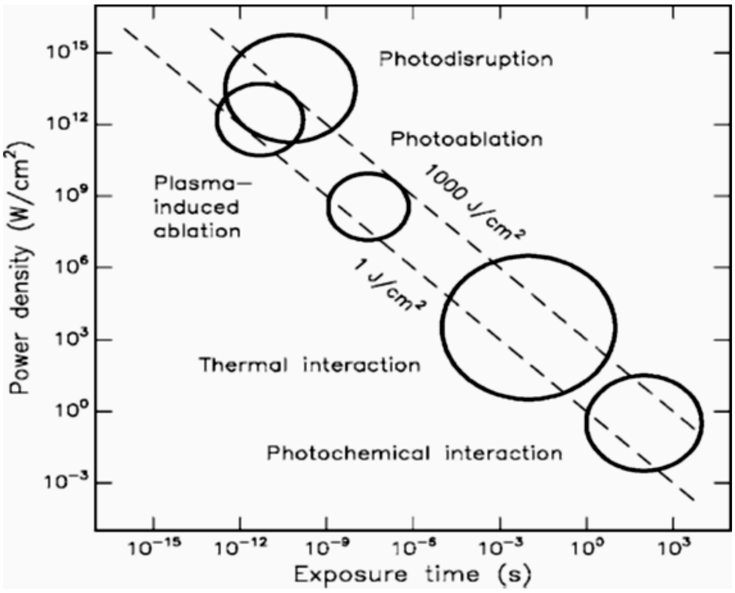


Figure (1.7) five interaction mechanisms depend on the duration of the light exposure and the irradiance, i.e. the power per unit area, in W/cm²

Laser tissue interaction can be either:

1. Wavelength dependent mechanisms.

2. Wavelength independent mechanisms.

1.4.6.1 Wavelength-Dependent Mechanisms

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. [37] These mechanisms are shown in figure 1.8.

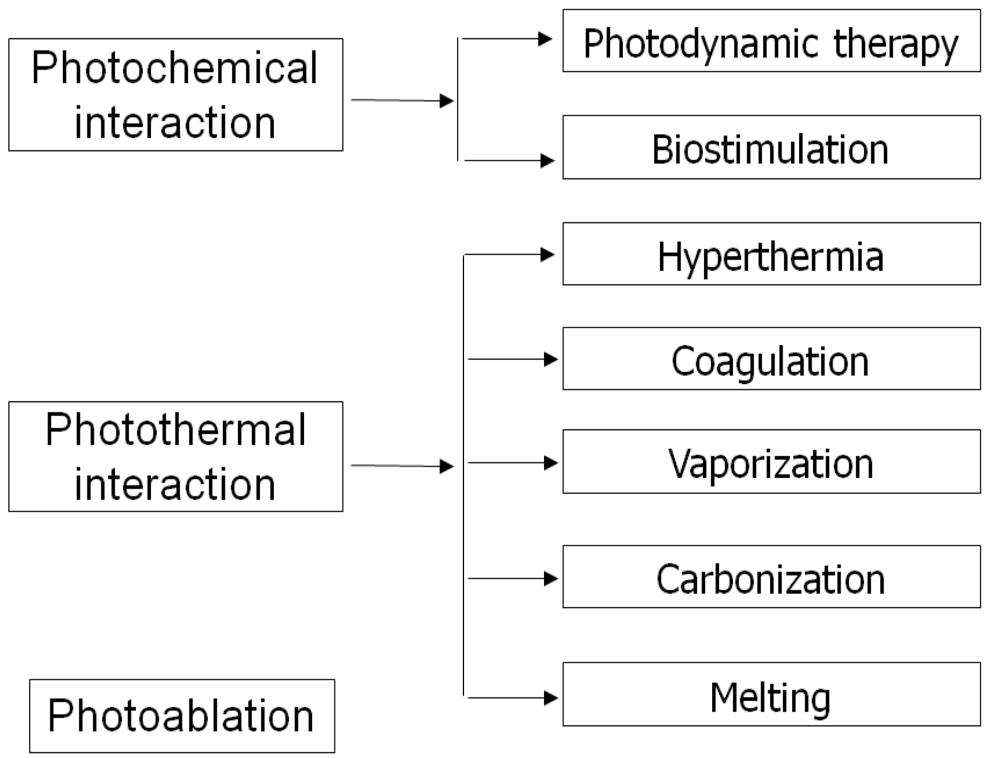


Figure (1-8) Wavelength dependent mechanism

1. Photochemical reactions:

In this type of interactions the light can induce chemical effects and reactions within macromolecules or tissues. In the photochemical interaction mechanisms play a significant role during photodynamic therapy (PDT). Frequently, bio stimulation is also attributed to photochemical interactions, Photochemical interactions take place at very low power densities (typically 1W/cm2) and long exposure times ranging from seconds to continuous wave.[37] Photochemical reactions occur with endogenous or exogenous photosensitizers, such as those used in photodynamic therapy, where light absorbing chromophores are introduced into the tissue and then elicit selective photochemical reactions by light absorption. [39] This photosensitizing drug absorb light, forming reactive oxygen species which is used to cause necrosis (cell death) and apoptosis (programmed' cell death), photodynamic therapy is increasingly widely used in oncology to destroy cancerous tumors .[39]

The generation of cytotoxic ROS in PDT requires the presence of oxygen, e.g. if the tissue is clamped to prevent blood from deoxygenating the tissue so the tissue becomes hypoxic (lack of oxygen) then photodynamic therapy does not work. [39]

2. **Photo thermal 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.

Table (1.1) Thermal effects of laser

Temperature	Biological effect
37^0 C	Normal
45^0 C	Hyperthermia
50^0 C	reduction in enzyme activity, cell immobility
60^0 C	denaturation of proteins and collagen, coagulation
80^0 C	increased permeability of membrane
100^0C	water vaporization, thermal decomposition (ablation)
>150 ^{0}C	Carbonization

A temperature increase in the tissue at temperatures above 100°C, the intracellular water exceeds the boiling point and vaporization occurs, which can be seen clinically as ablation of the tissue. [37]

The location and spatial extent of each thermal effect depend on the locally achieved temperature during and after laser exposure.[37] (Figure1-9).

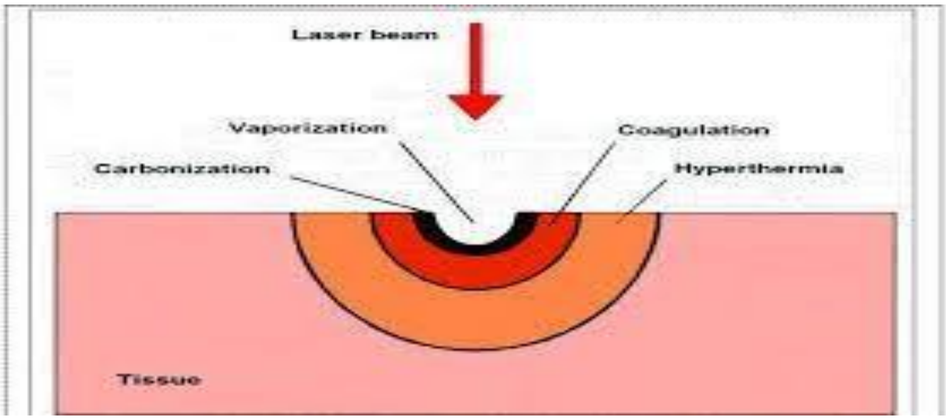


Figure (1.9) Location of thermal effects inside biological tissue

3. Ablative Photodecomposition (Photo ablation)

It is of high-energy, ultraviolet (UV) photon (from an excimer laser, e.g. ArF laser) is absorbed by electrons, causing virtually immediate dissociation of the molecules. This naturally leads to a rapid expansion of the irradiated volume and ejection of the tissue from the surface and there are no thermal effects associated with this process and it is therefore sometimes known as cold ablation. [39] Typical threshold values of this type of interaction are 10^7–10^8 W/cm2 at laser pulse durations in the nanosecond range. [37] Today, because photo ablation causes no thermal damage, and the very accurate etching that can be achieved, so it is one of the most successful techniques for refractive corneal surgery.[37, 39]

1.4.6.2 Wavelength-Independent Mechanisms.

1. Plasma-induced ablation

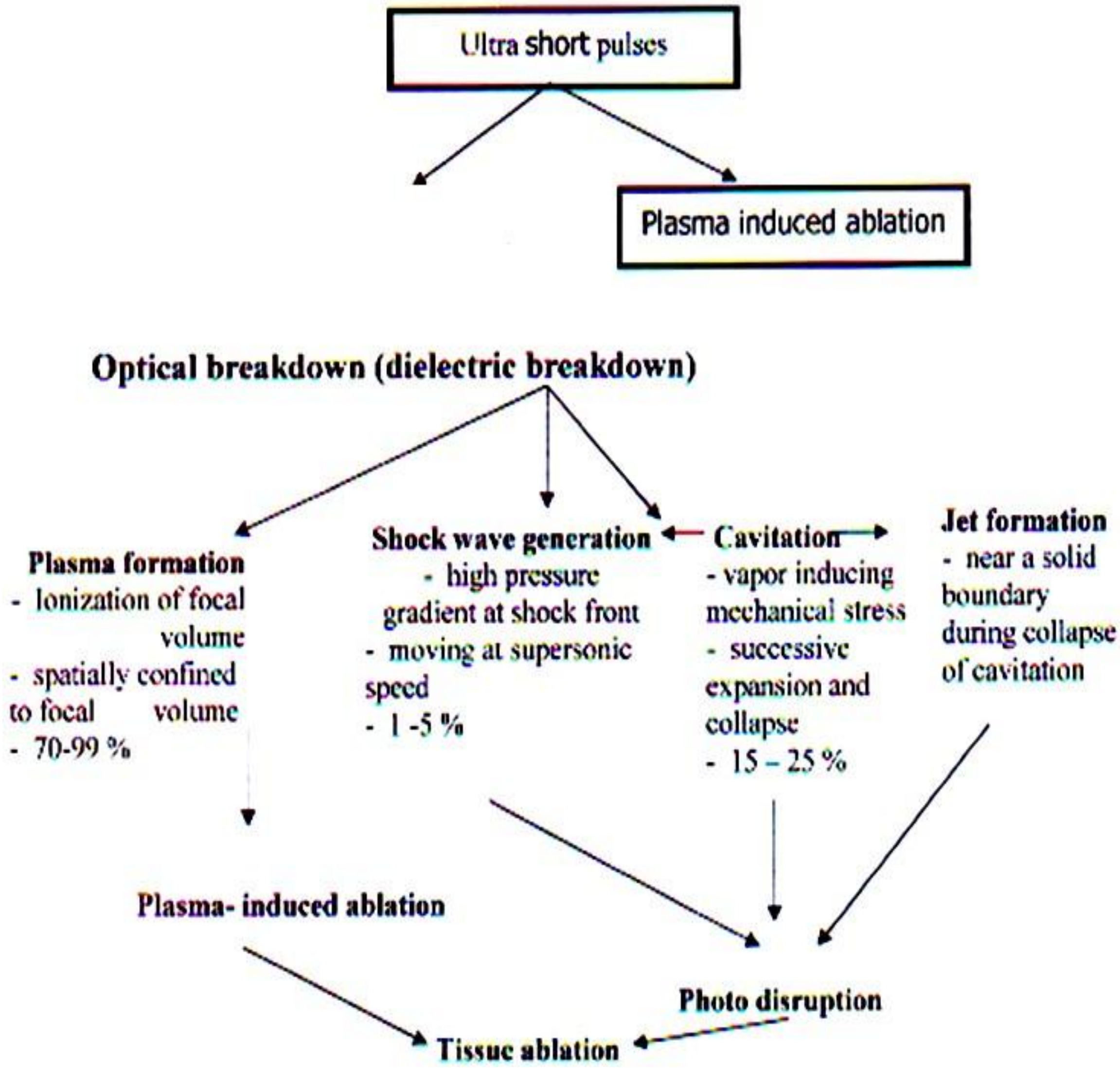
Plasma is a `soup' of ions and free electrons formed when sufficient energy is transferred to free a bound electron and a chain reaction of similar collisions is initiated. [37]

By means of plasma-induced ablation, very clean and well-defined removal of tissue without evidence of thermal or mechanical damage can be achieved when choosing appropriate laser parameters. [37] The principal advantages of plasma-induced ablation, sometimes called plasma-mediated ablation or laser-induced breakdown, are that: [39]

- The thermal damage is minimal (as with photo ablation).
- It is possible to ablate transparent tissue.
- When using fs and ps pulses the damage is well-confined.
- It is good for cutting close to tissue that must not be damaged, as the high absorption of the plasma has a shielding effect.

2. Photo disruption

It is the mechanical effects that can accompany plasma generation, such as bubble formation, cavitation, jetting and shockwaves. [39] The physical effects associated with optical breakdown are plasma formation and shock wave generation, if breakdown occurs inside soft tissues or fluids, cavitation and jet formation may additionally take place .[37] These can be used in lithotripsy [(53)]and in lens capsulotomy to treat posterior capsule opacification. [37] (Figure 1.10)



Figure(1.10) Scheme of the physical processes associated with optical breakdown.

Percentages given are rough estimates of the approximate energy transferred to each effect (incident pulse energy: 100%). Cavitation occurs in sof tissues and fluids only. In fluids, part of the cavitation energy might be converted to jet formation.

1.5 Laser Applications in Dermatology:

Most common types of laser used in dermatology shown in table (1-2), with their wavelengths and applications

Table (1-2) Dermatologic Lasers[40]

Wavelength (nm)	Laser	Indications
488-514 (blue-green)	Argon (continuous)	Telangiectasias, thick PWS in adults; epidermal pigmented lesions
504-690 (green-yellow-red)	Argon-pumped tunable dye (continuous)	Telangiectasias, thick PWS in adults; epidermal pigmented lesions; photodynamic therapy
510 (green)	Flashlamp-pumped dye (short-pulsed)	Epidermal pigmented lesions; red tattoos
511 (green)	Copper vapor/bromide (pseudo-continuous)	Epidermal pigmented lesions
521; 531 (green)	Krypton (continuous)	Epidermal pigmented lesions
532 (green)	KTP (pseudo-continuous)	Telangiectasias, thick PWS in adults; epidermal pigmented lesions
532 (green)	KTP (long-pulsed)	Telangiectasias, PWS in adults; epidermal pigmented lesions
532 (green)	Frequency-doubled Q-switched Nd:YAG (pulsed)	Epidermal pigmented lesions; red tattoos
568 (yellow)	Krypton (continuous)	Telangiectasias, thick PWS in adults
578 (yellow)	Copper vapor/bromide (pseudo-continuous)	Telangiectasias, thick PWS in adults
585-600 (yellow)	Flashlamp-pumped dye (long-pulsed)	PWS in adults, PWS in children, telangiectasias, warts, hypertrophic scars, striae
694 (red)	Q-switched ruby (pulsed)	Epidermal and dermal pigmented lesions; blue, black, and green tattoos
694 (red)	Ruby (long-pulsed)	Hair removal; dermal pigmented lesions
755 (infrared)	Q-switched alexandrite (pulsed)	Epidermal and dermal pigmented lesions; blue, black, and green tattoos
755 (infrared)	Alexandrite (long-pulsed)	Hair removal
810 (infrared)	Diode (long-pulsed)	Hair removal
1064 (infrared)	Q-switched Nd:YAG (pulsed)	Dermal pigmented lesions; blue and black tattoos
1064 (infrared)	Nd:YAG (long-pulsed)	Hair removal
1064 (infrared)	Nd:YAG (continuous)	Deep coagulation of tissue
1320 (infrared)	Nd:YAG (pulsed)	Nonablative skin resurfacing
2940 (infrared)	Er:YAG (pulsed)	Skin resurfacing
10600 (infrared)	Carbon dioxide (continuous; pulsed)	Coagulation, vaporization, and cutting of tissue; skin resurfacing

1.5.1 Fractional resurfacing

The search for laser rejuvenation alternatives was prompted by the high complication rates associated with traditional ablative resurfacing. The concept of fractional resurfacing was introduced in 2004 by Manstein et al. Fractional resurfacing produces clinical and histologic changes comparable to ablative lasers, but spares most of the skin and is characterized by rapid re-epithelization and mild side effects just like non-ablative resurfacing.[41]

The term “fractional” refers to treating a portion or fraction of the skin, without specification of laser type, spot size or wavelength. By treating only microscopic areas in one session, healing time is greatly reduced. Each treated area is surrounded by normal viable skin from which migration of keratinocytes occurs. Each treatment spot is termed a microscopic treatment zone (MTZ) which heals via migration of the normal surrounding epidermis, as opposed to healing via differentiation. Very high energies can be tolerated without bulk heating, and epidermal healing is completed within 36 hours. This rapid healing time reduces the incidence of infections, pigment alterations, and scarring. The higher the density, the closer together the MTZ will be, and the more agressive the treatment. Fractional devices come in two varieties: ablative and nonablative.[42]

1. 5.1. 1 Ablative fractional laser

The most recent generation of ablative lasers are the fractional ablative lasers, with the start of usage around 2007. These lasers have been able to reduce the trauma of the treatment and decrease downtime while retaining resurfacing power. They are significantly safer than their non-fractionated counterparts, but they still retain a high risk of potential damage in the form of scarring, discoloration, and skin infection .[43]The main use of these lasers is for mild skin tightening to battle laxity and rhytides. Overall, patients can expect moderate down time and moderate risk of complications.[44] Fractional technology was first developed in use with CO_2 lasers. Fractional technology can be applied to Er:YAG lasers. [45]

1.5.1. 2 Non-ablative fractional lasers

The 1410 and 1440 nm Nd:YAG, 1540 nm and 1550 nm erbium lasers, and 1927-nm thulium laser are non-ablative fractional lasers used to resurface the skin, reducing the appearance of superficial rhytides by micro-rejuvenation. [46]

1.6 Carbon Dioxide Laser

1.6.1 Overview

The carbon dioxide (CO_2) laser is still one of the important lasers used for medical surgery and industrial applications.[47] The carbon dioxide laser (CO_2 laser) was one of the earliest gas lasers invented by Kumar Patel of Bell Labs in 1964 and remains very useful. It is of the highest power continuous wave lasers that are available. It is an effective device; the ratio of output power to pump power reaches as high as 20%. The CO_2 laser produces a beam of infrared light with the principal wavelength bands around 9.4 and 10.6 micrometers.[47]

With a power range from mW to tens of kW in the cw mode and an efficiency of up to 30%, laser systems are compact and economic. The sealed laser tube is filled with a mixture of gases, CO_2 (1–9%), N_2 (13–45%), and helium (60–85%). Excitation occurs by direct current high-voltage gas discharge or through high frequency (RF). It must be mentioned that only with direct current supply units is the super pulse technique possible; it generates pulses <1 ms and with a peak power about ten times higher than the mean power.

The gas components have different reaction mechanisms during the laser process. The structure of the CO2 molecule is linear, with the carbon atom in the centre. Such molecule configurations can vibrate in symmetric and asymmetric stretch modes as well as in bending modes. The energies associated with molecular vibration are quantized just like electron energies; therefore, only certain vibrational levels are possible. The possible forms of resonant vibration are referred to as the vibrational modes of a molecule.[47]

1.6.2 Pulse Duration of Carbon Dioxide Lasers

Laser dwell time is the amount of time that the beam is on in one location. Low power densities require longer dwell times to achieve the same effect as high power densities. The longer the dwell time and the slower the heating, the more desiccation and charring of tissue that results. Further heating of charred tissue results in extremely high temperatures of 300–600°C. This is because carbonized and desiccated tissue acts as a heat sink for laser absorption. There is no buffer of water to absorb the heat and thus temperatures escalate rapidly. The significance is that if a non-pulsed laser is used, low pulse duration should be used to minimize thermal injury.[34]

1.6.3 Types of CO2 Lasers

Most clinicians use the super pulsed CO2 lasers, which deliver pulse energies in the 10–50 mJ range. The peak power per pulse is 2–10 times higher than CW CO2 lasers, but the average power over time is similar (Fig. 1.11). The ultra-pulse laser introduced by Coherent (now Lumenis) solved the problem of having to create second (duty cycles pulses of pulses) with the super pulsed lasers. This was the first laser capable of delivering very high fluence pulses (200–500 mJ) with large spot sizes capable of tissue vaporization with a single pulse. The depth of vaporization with an ultra-pulse laser was studied in pig skin using pulses of 250–450 mJ. In human skin, the depth of thermal damage using the ultrapulse laser was 20 μm after one pass, 40 μm after two passes, and 70 μm after three passes.[34]

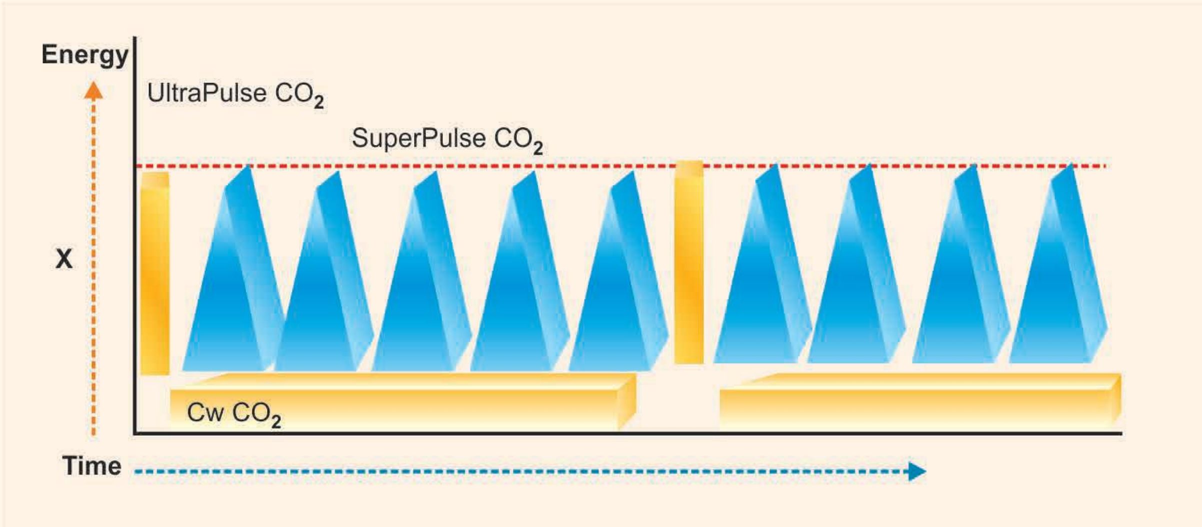


Fig. 1.11: A comparison of the waveform of CO2 laser. Note that for the same energy (X) generated by an ultra-pulse (<1 ms) waveform, 5 super pulse waves are generated. A continuous wave is seven times longer than the ultra-pulse for the same energy.[34]

1.6.4 Construction:

Because CO2 lasers operate in the infrared, special materials are necessary for thier construction. Typically, the mirrors are silvered, and the windows and lenses are made of either Germanium or Zinc Selenide. For high power applications, Gold mirrors and Zinc Selenide windows and lenses are preferred.There are also diamond windows and even lenses in use. Diamond windows are so expensive, but their high thermal conductivity and hardness make them useful in high power amplifications and in dirty environments.[37]

A basic form of CO2 laser consists of a gas discharge (with mix close to the specified above) with a total reflector at one end, and an output coupler (semi-reflective coated Zinc Selenide mirror) at the output end.

The CO_2 laser can be constructed to have CW powers between milli watts (mW) and hundreds of Kilowatts(kW). It is also very easy to actively Q-switch a CO_2 laser by means of rotating mirror or an electro-optic switch, giving rise to Q-switched peak powers up to gigawatts (GW) of peak power.[48]

Delivery system consists of: 1) Articulated arm 2) Hallow tube 3) Mirror joint 4) Lens 5) Hand piece.

1.6.5 Indications

1.6.5.1 Therapeutic

Actinic and seborrheic keratosis, warts, moles, skin tags, epidermal and dermal nevi, xanthelasma. Other conditions that have been shown to respond favorably to CO_2 laser resurfacing include dermatofibroma, rhinophyma, severe cutaneous photodamage (observed in Favre-Racouchot syndrome), sebaceous hyperplasia, syringomas, actinic cheilitis, angiofibroma, scar treatment, keloid, skin cancer, neurofibroma, diffuse actinic keratoses, granuloma pyogenicum, and pearly penile papules.[38]

1.6.5.2 Aesthetic

Periorbital and perioral wrinkles, facial resurfacing and acne scars, dyschromias including solar lentigines. [38]

1.6.6 Limitations to use of CO_2 laser:

1. Bleeding tendency.

2. Debilitating illness that affect wound healing.

3. Dark skin complexsion.

4. Psychosis.

5. Retinoid therapy, steroid therapy and anticoagulants.

6. Active herpes, warts or bacterial infection at the treatment zone.

7. Keloid diathesis.

8. History of radiotherapy or chemical burn.

1.6.7 Mode of action:

Ablative resurfacing has historically been performed using the CO2 laser. Since its introduction in 1968, it's used for rhytids, acne scars, actinic chelitis and other signs of photoaging.[42] At a wavelength of 10,600 nm, in far infrared spectrum, energy is preferentially absorbed by intracellular and extracellular water creating rapid heating and vaporization of tissue. New high energy short pulsed CO2 lasers and scanned CO2 produce relatively superficial tissue vaporization and minimizes deeper undesirable side effects like scarring and hypopigmentations.[41]

Thermal injury is prevented when the laser pulse width is less than the thermal relaxation time of the tissue. The critical pulse width is less than 1 millisecond. The first pass of the CO2 laser causes approximately 50-70 μm of ablation. Since the resulting layer of thermal necrosis has less tissue water than the uninjured skin, successive passes result in less tissue vaporization. With each pass, however, the total depth of thermal necrosis increases slightly,but does not exceed a depth of 100 μm if the pulse width is kept less than 1 millisecond.

It appears that thermal injury below the vaporization zone induces desiccation and collagen shrinkage, which serves as a scaffold for the formation and deposition of new collagen. Immunohistochemistry evaluations demonstrated up-regulation of procollagens I and II, interleukin 1-β, TNF-α, TGF-β1 and matrix.[41]

A given beam of CO_2 laser is delivered through a computer controlled device by computerized pattern generator (CPG) that automatically scan the area of skin being treated. Physicians can control the ablation and coagulation depth for either light or deep peels.[49]

Skin aging by environmental and sun damage cause the wrinkling effects. Skin resurfacing procedure can reverse these effects and restore a healthy look to the skin.[50]

Resurfacing approaches include: full field and fractional. In the full field resurfacing , the entire surface area of the skin is ablated. A laser beam is scanned across the treatment area and precisely removes a layer of damaged skin,then it will be replaced with a fresh healthy layer. Treatments can range from shallow (that appropriate for fine wrinkles, sun spots and tired looking skin) to deep (which is used to improve skin tone/ texture and deep wrinkles, even in difficult areas like upper lids and crow s feet).

In fractional resurfacing, the laser removes pinpoint columns of skin, leaving the surrounding tissue intact. This approach allows the laser to penetrate very deeply for effective collagen remodeling, while the surrounding intact tissue promotes rapid healing.[49-50] The main advantage of fractional CO_2 laser is the micro thermal zones of treatment and the sparing of interspaces of non-ablated skin that allows rapid healing with shorter down time. Most patients need 4-6 sessions to treat damaged skin. The results of fractional laser resurfacing are not immediate but evidence of smoother and tighter skin will be evident after 2-3 sessions.[51]

1.6.7.1 Skin resurfacing in layers:

Laser skin resurfacing is one of the recent ways to restore youthful look. For no one wants to look old and technical advancements have now come up with surer means of hindering the skin's aging process compared to the age-old herbals extracts and masks.

These technical developments have made it an effective and safer means of correcting the following conditions:

. Epidermal lesions. . Skin tumors.

. Dermal lesions. . Inflammatory dermatosis.

1.6.7.2 Modes of CO2 lasers used for skin resurfacing:

There are two major modes of CO2 lasers used for skin resurfacing.[52-53]

1. The continuous-wave CO2 laser: This is the earliest type of laser used in resurfacing. It has greater chances of associated thermal damage to adjacent skin tissues. This is called non-selective thermal damage that may induce scarring and pigmentation.

2. Rapid pulse lasers and flash scan CO2 lasers: These are newer and advanced techniques that ensure lower thermal damage to surrounding skin tissues other than the targeted ones. Essentially it targets tissue ablation more specifically and thus minimizes chances of leaving behind scars. This is achieved by decrease in the period of time the target tissue is exposed to laser radiation. The ultra pulsed Carbon Dioxide (UPCO2) laser is one of the most beneficial in adding the glow of youth to old, haggard facial skin.[52-53]

1.6.7.3 Laser resurfacing procedure:

There are certain factors associated with the laser resurfacing procedure. They are:

Fluence : fluence is the energy density necessary to thermally affect the target tissue. In case of laser resurfacing it idieally is 4.5 – 5.0 J/cm^2. Fluence greater than that and pulse duration less than 1 msec can target tissues up to a greater depth but causes thermal effect as well.[54]

1.6.8 Complications:

Many complications may occur during a laser resurfacing procedure. Some of the more common complications are: Erythema, swelling, infection dyspigmentation and scarring.[54]

1.6.9 Carbon dioxide (CO_2) Laser Tissue Interaction

The carbon dioxide (CO_2) laser emits light at a wavelength of 10 600 nm. Its photo thermal effect on tissue consists of the transformation of water into vapor, which leads to complete cell vaporization .However, as the CO_2 light only penetrates 0.3–1mm into the target and, the thermal damage to the tissue beyond the vaporization area is minimal.

In practical terms, the CO_2 laser is applied in a non- contact technique in CW and about 15W.As the laser light is in the far-infrared band, visual control can be achieved by the addition of visible guiding beam, such as a helium-neon or diode laser to mark the aimed focal spot.[37] It is often used in the super-pulsed wave mode, which produces power peaks that are about ten times higher than the CW mode. This allows application with more precision and less thermal injury as the surrounding tissue can cool down between the power intervals. The CO_2 laser cannot be used for sealing vessels of more than 0.5 mm in diameter, The CO_2 laser is mainly a surgical tool. It can cut or vaporize tissue with fairly little bleeding as the light energy changes to heat. This type of laser is used to remove thin layers from the surface of the skin without going into the deeper layers. A carbon dioxide laser kills tissues by destroying cells. When touched by this type of laser, tissues that are composed of 80 percent to 90 percent water are destroyed by the steam formation in the cells. The area that is vaporized by the laser is both localized and also does not present any combustion because the intracellular temperatures never go beyond 100 degrees Celsius. Moreover, there is also very little damage to the surrounding areas, CO_2 laser is the standard laser in surgery. Depending on the type of treatment, CO_2 lasers can be operated in three different modes – CW radiation, chopped pulse, and super pulse. [37]

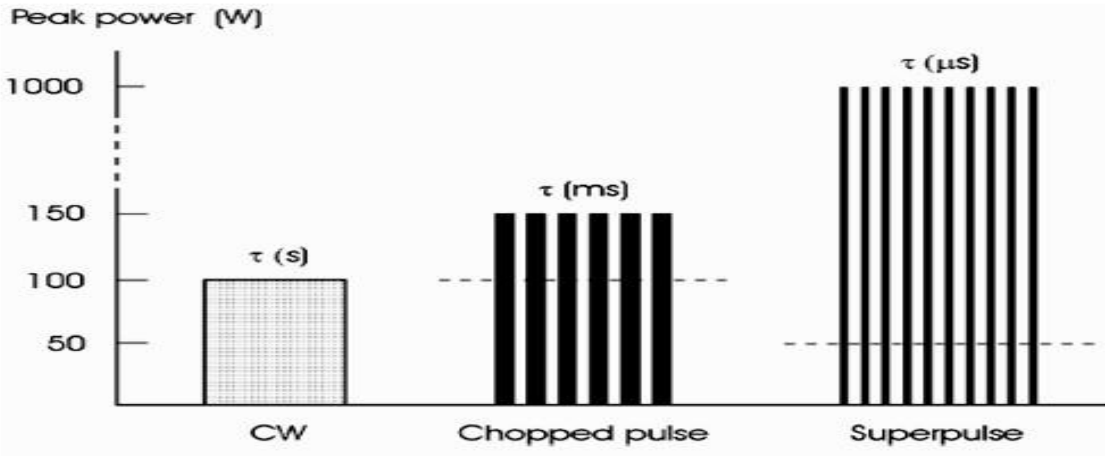


Figure (1.12) CW, Chopped pulses, and super pulses mode of a CO2 laser. Dash line denote mean power

As shown in Figure.(1.12) Chopped pulses with durations in the millisecond range are obtained from CW lasers when using rotating apertures, Superpulses are achieved by modulation of the high voltage discharge, Thereby, pulse durations less than 1 ms can be generated. The peak power is inversely related to the pulse duration. The mean powers of CW radiation and chopped pulses are nearly the same, whereas it decreases in the case of superpulses. Shorter pulse durations are associated with a reduction of thermal effects. Hence, by choosing an appropriate mode of the laser, the best surgical result can be obtained.[73] Besides selecting the temporal mode, the surgeon has to decide whether he applies a focused or defocused mode as shown in Fig. (1.13).Only in tightly focused mode are deep excisions achieved. In partially focused mode, less depth but a larger surface is vaporized. In defocused mode, the power density decreases below the threshold of vaporization, and tissue is coagulated only.[37]

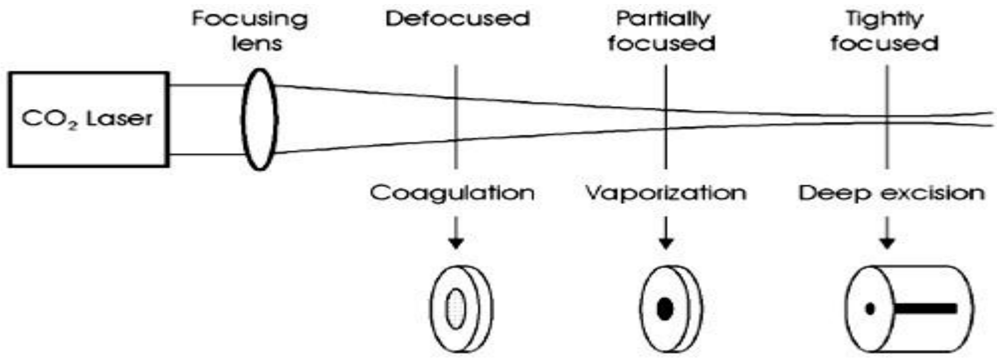


Figure (1.13) Coagulation, vaporization, and excision modes of a CO2 laser. Depending on defocused, partially focused, or tightly focused beam.

Because of its very long and Far-IR wavelength, the CO_2 beam has a very shallow absorption depth and a great affinity for water and almost everything including glass and fiber optics. Though the beam must be delivered via mirrors mounted in an articulated arm, the CO_2 makes a great surgical “light” scalpel and ablator. When used with a scanner or pattern generator, cosmetic skin resurfacing is easily achieved. The treatment can be fractional or totally ablative. Developments in fiber optics made it possible to transmit far-infrared laser beams, increasing the flexibility of CO_2 lasers for endoscopic surgery.[55]

1.7 Laser radiation hazards and damage mechanism

Hazards from the laser include direct and indirect (reflected) beam exposure; fire hazards; smoke produced by vaporization (containing pathogen and chemical toxins. Table 1.3 summarizes laser hazards:

Table 1.3: Laser hazards [76]

Laser radiation hazards	Eye	Corneal or retinal burn(depending on wavelength) Cataract Retinal injury
	Skin	Skin burn from acute exposure(direct or reflected beam) Skin carcinogenesis(depending on wavelength)
Chemical hazards		Eximer,dye,chemical lasers contain toxic substance Smoke produced from vaporization or laser induced reactions
Electrical hazards		Danger from high power voltage supplies.
Secondary hazards		Cryogenic coolant hazards Excessive noise X-radiation (from high voltage power supplies). Fire hazards(from beam exposure to flammable substances).

1.7.1 Bio-effects of the eye and skin

The Table (1-4) below summarizes the various medical conditions to the eyes and the skin caused by lasers at different wavelengths.[57,58]

Table (1.4) Bio-effects of the eye and skin

SPECTRUM	EYE EFFECT		SKIN EFFECT
	Location	Effect	
UV-C (200-280 nm)	Cornea	Photo keratitis	Erythema, cancer, accelerated aging
UV-B (280-315 nm)	Cornea	Photo keratitis	Erythema, increased pigmentation, cancer, accelerated aging
UV-A (315-400 nm)	Lens	Cataract	Erythema increased pigmentation, skin burn
Visible (400-780 nm)	Retina	Retinal injury*	Photosensitive reactions, skin burn
IR-A (780-1400 nm)	Retina, Lens	Retinal burn, cataract	Skin burn
IR-B (1400-3000 nm)	Cornea, Lens	Corneal burn, cataract	Skin burn
IR-C (3000-1000000 nm)	Cornea	Corneal burn	Skin burn

* Retinal injury can be thermal, acoustic or photochemical.

1.7.2 Safety with the CO2 Laser

Safety with lasers is paramount for the well-being of the patient and all in the operating room. This is particularly so for the CO2 laser given its range of use in deliberate destructive indications. As the eye is the most vulnerable target for optical energy, eye protection is mandatory for all in the treatment room. However clear glass or plastic will stop the CO2 beam completely: this is why normal quartz fibers cannot be used as a beam transmission system for the CO2.

Ordinary prescription lenses can be used, but dedicated glasses or goggles incorporating lateral shields are always recommended. The 10,600 nm beam is also a “safe” wavelength for the eye, or at least the retina, because all of the energy will be absorbed in the water in the cornea at the front of the eye. This makes the CO2 laser marginally safer than the visible and near-infrared lasers, because the latter will pass straight through the cornea, be focused by the lens, and severely damage the macula/fovea complex in the retina. Protecting the patient is also a priority, and for the CO2 laser this means draping the skin around the target area with damp drapes or gauze, and keeping these materials damp throughout the procedure because the CO2 energy is absorbed in water. If a beam of CO2 energy strikes dry gauze or cotton, the potential for starting a fire is very high. When using the CO2 laser to excise tissue held under traction, a backstop of some kind should be employed, either a dampened wooded tongue depressor or a damp cotton bud depending on the site. Finally, as already discussed, the laser plume created by the CO2 laser can contain potentially harmful substances such as viable viral particles, [59] so the use of a dedicated smoke evacuator is extremely important. The use of masks alone will not suffice.

1.8 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.[60]

1.8.1 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.[61]

1.9 Literature review

A total of nine studies were included that utilized the CO2 laser to treat patients with xanthelasma palpebrarum. [15, 23, 62-65] Included studies discussed a total of 165 patients with ages varying between 26 and 75 years. Overall, the outcome was excellent, with complete initial resolution achieved in all studies save one, [63] in which outcome was graded on a qualitative “good” to “excellent” scale. Recurrence occurred in 13 patients (7.8%).[15, 23, 62] In most cases, the outcome was achieved with 1–3 treatment sessions at 2-week intervals, when specified.

Esmat and colleagues[65] prospectively compared efficacy of the superpulsed and fractional CO2 lasers. Forty-eight lesions on 20 included patients were randomly assigned to 1 session of total lesion ablation with superpulsed CO2 laser or 3–5 sessions of fractional CO2 laser therapy at 4–6 week intervals. Both modalities successfully removed lesions. However, the superpulsed CO2 laser demonstrated significantly better scores of improvement in lesion color and thickness, when compared with those treated by fractional CO2 laser. For those patients treated with fractional CO2 laser, downtime was significantly shorter (average 5.8 d vs. superpulsed 12.3 d, P = 0.001). In addition, patient satisfaction was significantly improved with use of the fractional laser, particularly those with lesions of large surface area. Scarring (n = 11) and recurrence (n = 3) rate were found to be higher in the superpulsed-treated group, whereas no evidence of scarring and recurrence were observed in the patients treated with fractional CO2 laser.

Another study[63] compared CO2 laser efficacy with that of topical trichloroacetic acid (TCA) in 30 patients with xanthelasma palpebrarum. Patients receiving TCA were randomly assigned to concentrations of 35, 50, and 70% TCA peeling every 2 weeks for a maximum of six sessions or until clinical cure. Six patients received CO2 laser therapy. Increasing TCA concentration reduced the number of sessions required. However, no significant differences were found in efficacy between 70% TCA and CO2 laser. Two patients with lipid abnormalities developed recurrent lesions after 35% TCA and CO2 therapy, respectively. Goel et al.[62] also compared efficacy of monthly ultrapulsed CO2 laser therapy with weekly 30% TCA in xanthelasma palpebrarum treatment. The complete cure rate was higher in the group receiving CO2 laser therapy (25 of 25), when compared to those receiving TCA (14 of 25). Additionally, mean number of sessions was lowered in the laser group, except in those with mild disease. However, no significant differences were detected in scarring and recurrence rates.

Reported adverse events typically included transient dyspigmentation, erythema, and scarring. Transient dyspigmentation was the most consistently reported adverse outcome, with hypopigmentation reported in 17 patients[63-65]and hyperpigmentation reported in 10 patients.[15, 23, 62-65] Mild erythema and edema were additional common complaints. Esmat et al.[65] reported atrophic scarring (n = 11) and upper eyelid retraction (n = 2) with use of the super pulsed laser. These effects were not reported in the remaining studies, which generally used ultra-pulsed lasers or did not report CO2 laser type.

1.10 Aim of the study:

To evaluate the efficacy and safety during the follow up period of fractional CO_2 laser (10,600nm) in the treatment of xanthelasma palpebrarum in a sample of Iraqi patients.

Chapter two

Patients

And

Methods

Chapter Two

Patients and Methods

2.1 Introduction

This was a therapeutic intervention study done at the laser unit clinic of the Center of Dermatology and Venereology in the Medical City-Baghdad, during the period from October 2020 to February 2021.Ten patients with xanthelasma palpebrarum were selected for CO2 laser treatment.

2.2 Patients descriptions

The study enrolled ten (10) adult patients (8women and 2 men) aged 35 to 50 years (mean, 43). All patients had Fitzpatrick skin photo- types III–IV. With twenty –four (24) XP lesions, fourteen (14) lesions on left eyelids and ten (10) lesions on right eyelids. At presentation, 2/10(20%) patients had single lesion and 8/10(80%) had multiple lesions.

Table 2-1: Patient demographics

Age range/Age Mean (years)	35-50/43
Sex	
Female/male	8/2(80/20%)
Family History of similar lesions	Nil
Lesion characteristics	
Site of lesion	
Upper eyelid	21
Lower eyelid	3
Both eyelids	9
Bilateral lesions	8/10(80%)

Table 2-2:Patients Statistics

	No. of the affected eyelids*				
	1	2	3	4	Total
No. of patients	2	3	4	1	10
%	20%	30%	40%	10%	100%

* Number of eyelids involved in the same patient.

2.2.1 Inclusion criteria

Patients should have at least single lesion of xanthelasma of any type (macular, papular, or plaque).Patients should not have received any prior treatment for xanthelasma with any modality in the last one year. All patients included had not received any prior treatment with any modality except for three patient had a laser therapy before more than one year. In three cases the xanthelasmata were thin and macular and in the remainder a mixture of macular, papular and plaque lesions.

2.2.2 Exclusion criteria

Pregnant or lactating females, patients with history of hypertrophic scars, keloids, systemic retinoid therapy within the last 6 months, subjects with a known history of herpes labialis infection, hyperlipidemia and those with coagulation disorders were all excluded.

2.2.3. Ethical considerations

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

2- Informed consent was taken from patients before being enrolled in the study.

2.3 Methods

2.3.1. Data Collection

All patients were subjected to the following: full detailed history (age, sex, onset, course, duration of the lesion, associated disorders(especially diabetes mellitus, hypertension and hypothyroidism), history of medications, and so on), complete medical examination, and dermatological assessment of XP lesions regarding their area, number, color, and thickness. In addition, serum lipid profile (total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, and triglycerides) was evaluated and all patients were normolipidemic.

2.3.2. Evaluation criteria

Therapeutic outcomes were assessed by standardized digital photography by the patient himself and by two dermatologists.

Medical evaluation was independently evaluated using the following well-established quartile grading scale: grade 1 (<25%) indicates minimal to no improvement; grade 2 (26%-50%), moderate improvement; grade 3 (51%-75%), good (marked) improvement; and grade 4 (>75%), excellent (near-total) improvement as shown in table (2-3)

Table 2-3:Quartile grade of improvement

Grade	1	2	3	4
Improvement	Minimal	Moderate	Good	Excellent
	<25%	25-50%	51-75%	>75%

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 non-realistic 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 CO2 laser system 10,600 nm (SmartXide Touch, advanced CO2 fractional technology; DEKA, Florence, Italy) (Figure 2-1) has been used in this study and it's the following specifications (Figure 2-2).

Figure 2-1: Smartxide Touch Deka CO2 Laser Device and its hand piece.

Technical Data

SmartXide Touch - Configurations in Dermatology and Aesthetic Medicine*	
Laser Type & Wavelength	CO_2 RF – PSD® emitting at 10.6 μm with emission beam mode TEM_{00}
Emission Modes	CW - SP - DP - HP - UP
Power	CW: from 0.5 to 60 W; SP: from 0.1 to 15 W; DP: from 0.2 to 15 W; HP: from 0.1 to 8 W; UP: From 0.5 to 60 W
Emission Time & Delay	Emission Time: from 0.01 to 0.9 s. Delay: from 0.3 to 5 s
Beam Delivery	7-mirrors articulated arm
Aiming Beam	Laser diode @ 635 nm - 4 mW - Adjustable intensity from 1% to 100% Diode OFF while lasering (DOWL).
Internal Database	About 150 factory stored protocols, upgradable by USB. Possibility of storing unlimited custom user's protocols.
Control Panel	Wide LCD Colour Touch Screen (8.4")
Accessories*	HiScan DOT/RF Scanner System. Wide range of handpieces.
Electrical Requirements	From 100 to 230 Vac (automatic selection). 1,200 VA - 50/60 Hz.
Dimensions** and Weight	118 (H) x 42 (W) x 54 (D) cm - 62 kg
HiScan DOT/RF Scanning System	
Max Scanning Area	15 x 15 mm
Dwell Time & DOT Spacing	Dwell Time: from 100 μs to 2,000 μs. DOT Spacing: from 0 to 2,000 μm
SmartStack Level	From 1 to 5
Scanning Shapes	DOT, Line, Triangle, Parallelogram,Exagon, Square
Scanning Modes	Normal, Interlaced, SmartTrack
Emission Modes	SP, DP, HP (DOT Fractional Scanning Mode) CW (Standard Scanning Mode)
RF Power	From 5 to 50 W
RF Dwell Time	From 0.5 to 10 s

The scanner can be connected to a SmartCryo system to enable continuous cooling and thus preserve the more superficial layers of the skin. It is also available an accessory with a dedicated connection adaptable to the most diffused smoke evacuators.

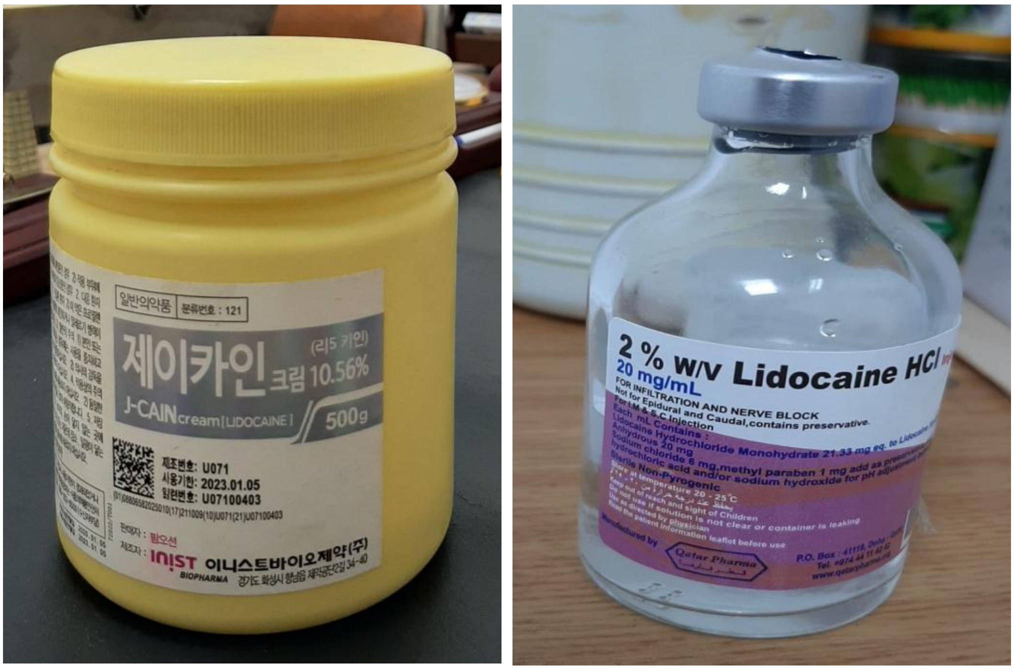
*In this catalogue only the technical features of the Dermatology and Aesthetic Medicine applications are listed.
** Height with folded articulated arm.

Figure 2-2: Smartxide Touch Deka CO2 Laser Specifications.

2.5 Technique

2.5.1 Topical anesthesia:

Topical anesthetic cream (10.56% lidocaine cream) was applied to the areas to be treated 60 minutes before the laser session. Additional infiltration anesthesia (2% lidocaine HCL) via standard insulin syringe attached with a 30-G needle for further mitigation of pain (Figure 2-3).



(A) **(B)**

Figure 2-3: Topical anesthesia A-Topical lidocaine cream (10.56%),
B- Lidocaine injection 2%.

2.5.2 Safety measures 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 (doctors and medical staff) present during the procedure asked to 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 CO2 laser. The doctor goggles were transparent for CO2 Laser. (Figure 2-4 A). The patients were asked to close the eyes, warned to keep their eyes closed remain still during the entire treatment, for extra protection metal eye shields (Figure 2-4B) inserted and this is usually lubricated with chloramphenicol ointment to minimize any corneal abrasion.

The contralateral eye was covered with saline-soaked gauze.

(A)

(B)

Figure2-4: Eye protective measures. A-Physician goggles B-Eye shields of different sizes (large and small size).

2.5.3 Photos

All patients were photographed before treatment with a digital camera (Sony DSC-T700 Cyber-shot® Digital Camera, 10.1 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 observers who had to determine the before and after pictures, and had to categorize the improvement using the quartile grading scale.

2.5.4 Laser therapy and parameters

Xanthelasma palpebrarum lesions treated by ablative fractional CO2 laser (SmartXide Touch, advanced CO2 fractional technology; DEKA, Florence, Italy) (Figure 2-1) received 1 to 3 sessions with 2 to 4 weeks of intervals with the following parameters(Figure 2-5):

-Power 35 W

-Energy fluence 39.10 J/cm^2

-Pulse energy 47.9 mJ

-Spacing 0 micrometer (µm)

- Density 78.5%

-Dwell time 1000 microsecond (µs)

-With (4-7) passes

Figure 2-5: Laser paramerers used

2.5.5 Procedure

After each pass, the debris (charred tissue) was gently removed with a normal saline soaked gauze piece to expose the planes. End point of treatment was determined either by the ablation of the lesion or by the appearance of pinpoint bleeding. This end point was useful while treating the raised lesions as the residual thermal damage extends from 0.5 to 1 mm beyond the level of ablation; thus, the end point was not the complete ablation of the lesion.

The number of sessions, intervals in between, and the number of passes were variably recruited until complete elimination of the lesions or a maximum number of 3 sessions is achieved whichever comes first.

2.6 Postoperative Instructions

All patients were given systemic antibiotic therapy (cephalexin capsule 500mg four times per day) for 1 week after laser session. They were also instructed to apply topical antibiotic ointment (fusidic acid), topical and systemic antibiotics used as a prophylactic measure. Patients were told to avoid sun exposure for at least 6–8 weeks and to apply sun protection(zinc oxide ointment) on treated areas and to avoid any unnecessary sun exposure for 7 days after treatment, and to avoid friction of the treated areas to prevent improper wound healing.

2.7 Follow- up

Patients were evaluated at day seven, two weeks, 1 month, and finally at 3 months after the treatment session (last session) for the occurrence of complications such as dyspigmentation (hyperpigmentation /hypopigmentation), scarring, and pain. The rate of recurrence was reported as well, during the follow-up period (3 months after the last session). Patient satisfaction was evaluated by reporting downtime, the incidence of pain, the need for intradermal anesthesia to tolerate the procedure, the incidence of complications, and recurrence rate. All patients were photographed at baseline, one month after each session of fractional CO_2 laser, and three (3) months after the last session using a digital camera.

Chapter three
Results and Discussion

Chapter Three

Results and Discussion

3.1. Introduction:

In this chapter results would be clarified, discussed and compared with other similar studies.

3.2. Results:

The results of this study depend mainly on the clinical observation by inspection, patient complaints during operation and clinical postoperative follow-up. All procedures were performed in an outpatient setting.

This study included ten (10) patients with xanthelasma palpebrarum (XP) (8 women [80%] and 2 men [20%]) whose ages ranged between 35and 50 years (mean 43). The duration of the disease ranged from 4 to 36 months (mean 13). Three patients (30%) had previously undergone laser therapy before more than one year. The skin lesions varied in size from 3mm to 3cm. The total number of treated XP lesions was 24, and the majority involved the upper eyelid (21 lesions on the upper eyelid and 3 lesions on the lower eyelid). Three patients (30%) had 3 lesions involving both upper and lower eyelids.

The majority of patients responded well to the treatment (8 patients, 80%) with complete removal after one session in a total of 20 lesions, other 2 patients (20%) needed more than one session(2and 3 sessions)for complete removal with a total of 4 lesions. All XP lesions on both sides were successfully removed with significant improvement in area, color, and thickness.

All patients have had satisfactory resolution of xanthelasma palpebrarum with excellent cosmetic effect, and thus far, no recurrences have been noted during the study period. Patients' data are shown in table (3.1)

Table 3.1: Patients data:

No. of patient	Age	Sex	No. of Lesions	Location of lesion on the eyelid	No. of sessions	Improvement Grading scale*/Patient satisfaction grade	Results/Outcome
1	47	F	2	Upper	1	4/ Excellent	Cleared
2	40	F	3	Upper &lower	3	3/Good	Incomplete clearance
3	50	F	3	Upper &lower	1	4/ Excellent	Cleared
4	44	F	1	Upper	1	4/ Excellent	Cleared ,Transient hypopigmentation
5	39	F	2	Upper	1	4/ Excellent	Cleared ,Transient hypopigmentation
6	39	F	3	Upper	1	4/ Excellent	Cleared
7	41	M	3	Upper & lower	2	3/Good	Incomplete clearance
8	50	F	4	Upper	1	4/ Excellent	Cleared
9	35	M	2	Upper	1	4/ Excellent	Cleared
10	45	F	1	Upper	1	4/ Excellent	Cleared

*Scale:1=0-25%,2=26-50%,3=51-75%,4=76-100%.

TABLE 3.2 Patients Results

	NO. of Patients	%
Excellent	8	80
Good	2	20
Moderate	0	0
Mild	0	0

A 8 patients (80%) were highly satisfied (excellent) and 2 patients (20%) reported for good grades as shown in Table (3-3)

Table (3-3): Percent of patient satisfaction grade:

Grade of satisfaction	Excellent	Good	Fair	Poor
% of patients	80	20	0	0

Minimal redness and swelling last 24-72 hours after treatment, these resolved by using systemic and topical antibiotics. Downtime was mostly 2 to 3 days. Undesirable effects were reported mainly erythema in 10 (100%) patients, and swelling in 10 (100%) patients. These started shortly after sessions (within few hours), erosions and crusting were noticed in 3(30%) patients, which was controlled by topical and systemic antibiotics as a prophylactic measure, Fortunately, no infection was reported in this study.

No case of dyspigmentation reported except for two patients (20%) who developed transient hypopigmentation,which disappeared after a few weeks ,and no scarring occured.

The procedure was comfortable apart from mild discomfort experienced by half of patients (50%)and a mild pain in one (10%) patient.

At the 3-month follow-up visit after the last treatment, the evaluating physician noted grade (4) improvement, with no post-procedural complications or recurrence. The patient’s degree of satisfaction agreed with the physician’s assessment of improvement.

(A)

(B)

(C)

(D)

Figure 3-1: A 40 years old female patient. (A) Before (B) after two days

(C) After one month (D) after three months.

(A)

(B)

(C)

(D)

Figure 3-2: A 50 years old female patient (A) before (B) immediately after Laser ablation (C) after two week (D) after one month).

(A)

(B)

Figure 3-3: A 47 years old female patient. (A) Before laser ablation and (B) After three months.

(A)

(B)

Figure 3-4: A 50 year female.(A): before (B): After 3 months.

3.3 Discussion

Different modes of ablative CO2 laser were applied for XP therapy. The continuous mode with the resulting scarring and asymmetrical retractions and the ultrapulsed mode with improved technology leaving time for thermal relaxation while vaporize a thin layer of tissue.[15]

With a wavelength of 10,600 nm in the mid-infrared region, CO2 laser energy is well absorbed by water. The high water content of the skin makes CO2 laser ideal for precise and safe ablation of skin lesions. CO2 laser can seal off blood vessels with diameter <0.5mm through a thermal coagulation effect, and therefore, bleeding rarely occurs during ablation of XP lesions, which have small and few blood vessels. In this study, bleeding was noted during clearing of the basal layers of the XP lesions. This is to be expected because dermal tissue, which is rich in blood vessels of different diameters, is exposed as the basal layers are cleared. The number and size of the exposed blood vessels tend to be more in larger lesions.

The superpulsed and ultrapulsed modes of CO2 laser have been demonstrated for XP therapy, but few studies have been published in the literature evaluating the fractional mode which can be considered as a safe therapeutic option.[20]

This study introduces fractional CO2 laser as an effective modality for the treatment of XP. All lesions were successfully removed with improvement in color, area, and thickness.

Fractional ablative CO2 laser was used by Roh and colleagues[66] who also demonstrated significant improvement of XP lesions in 15 adult patients after treatment with fractional CO2 laser. Nevertheless, this study was published as a preliminary one and did not include details regarding the parameters used, results, complications, or the scoring systems recruited to evaluate the efficacy of the therapeutic procedure.

The results in this study are comparable to the results of Esmat et al, [65] who compared the superpulsed and fractional CO2 lasers. XP lesions were efficiently removed by both methods. XP lesions treated by ablative fractional CO2 laser (SmartXide DOT, advanced CO2 fractional technology; DEKA, Florence, Italy) received 3 to 5 sessions with 4 to 6 weeks of intervals with the following parameters: power 20 W, spacing 500 µm, dwell time 500 to 700 µs (1–3) passes. We notice that, the number of sessions is more than that used in this study and this can be explained due to the parameters used in this study which are:(1) the power is more (35 W), (2) the dwell time is more (1000 µs) ,(3)spacing is less(0),and the increasing no. of passes (4-7); as the longer the dwell time and the slower the heating will results the more desiccation and charring of tissue.

This is the same in comparable to Alkady et al, [67] who compared the fractional CO2 laser and 50% concentration TCA,ablative fractional CO2 laser used (10 600 nm wavelength) (SmartXide DOT, Deka, Florence), with power 20-watt, dwell time 700 µs, spacing of 500 µm, Smart Stack level 1-3, and 1-3 passes, was used with fine adjustment depending on skin type and patient's reactions.

The superpulsed CO2 laser showed better scores of improvements in lesion color and thickness. This can be explained that some lesions treated by fractional CO2 laser needed more sessions to be removed completely.

Regarding the incidence of complications, there was no evidence of either scarring or recurrence at the site of lesions treated by fractional CO2 laser during the follow-up period (3 months) after the last session,just for reported common complications involved transient dyspigmentation, mild edema, and erythema Two factors may contribute to the incidence of hypopigmentation in patients with medium skin types (III-IV): (1) the high contrast with surrounding normal skin and (2) the limited compensatory ability of the melanocytes in the adjacent areas, leading to a longer recovery time. In this study, the transient hypopigmentation took 1-2 months to resolve completely, comparable with 6-9 months in treatment with ultra-pulsed CO2 laser in skin types III-IV Chinese patients.[68]

Retraction and scarring reported in the superpulse and ultrapulse modes because of using the full ablative technique, while the MTZs created by the fractional CO2 laser allow limited ablation with optimum healing, collagen remodeling, and rejuvenation with less risk of scarring.[53]

No recurrence detected in this study, this can be explained by the trans-epidermal elimination of dermal lipids induced by fractional laser through the MTZs through melting the lipid by the heat produced by the laser.

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Conclusion & Suggestions

Conclusion

In conclusion, ablative fractional CO_2 laser is an effective and safe therapeutic option for xanthelasma palpebrarum, offering significantly short downtime, high patient satisfaction, few sessions, and mild complications. Based on the findings in this study, its use is especially recommended in lesions of redundant upper eyelids and those occupying large surface area for a better cosmetic outcome.

Suggestions

Suggestions for future work:

1. Increase the numbers of patients in the study.

2. Make a comparative study between Fractional CO_2 laser and other lasers like Erbium:YAG laser including the effectiveness, safety and side effects.

3. Extension of the follow up period for 12 months after the last session.

References

References

1. Jain A, Goyal P, Nigam PK et al. Xanthelasma palpebrarum– clinical and biochemical profile in a tertiary care hospital of Delhi. Indian J Clin Biochem 2007; 22: 151–3.

2. Christopher Griffiths, Jonathan Barker, Tanya Bleiker ,et al. Rook's Textbook of Dermatology, 9th edn. Wiley-Blackwell; 2016: Vol. 2:.62.4: Xanthomas and abnormalities of lipid metabolism and storage.

3. Laftah Z, Al-Niaimi F. Xanthelasma: An update on treatment modalities. J Cutan Aesthet Surg 2018; 11:1-6.

4.James WD,Elston DM,Treat JR, eds. *Andrews' Diseases of the Skin.* 13th ed.,Elsevier Inc; 2020:p.532.

5. Cannon PS, Ajit R, Leatherbarrow B. Efficacy of trichloroacetic acid (95%) in the management of xanthelasma palpebrarum. Clin Exp Dermatol 2010; 35: 845–8.

6. Haque MU, Ramesh V. Evaluation of three different strengths of trichloroacetic acid in xanthelasma palpebrarum. J Dermatolog Treat 2006; 17: 48–50.

7. Basar E, Oguz H, Ozdemir H et al. Treatment of xanthelasma palpebrarum with argon laser photocoagulation. Argon laser and xanthelasma palpebrarum. Int Ophthalmol 2004; 25: 9–11.

8. Fusade T. Treatment of xanthelasma palpebrarum by 1064-nm Q-switched Nd:YAG laser: a study of 11 cases. Br J Dermatol 2008; 158: 84–7.

9. Sonthalia S, Arora R, Sarkar R. Successful cosmetic ablation of xanthelasma palpebrarum with low-voltage radiofrequency: back to the basics. *Dermatol Surg*. 2014; 40:1443-1444.

10. Christopher Griffiths, Jonathan Barker, Tanya Bleiker, et al. Rook's Textbook of Dermatology, 9th edn. Wiley-Blackwell; 2016: Vol. 3; 109: Dermatoses of the eye, eyelids and eyebrows.

11. Pragya A Nair, Rochit Singhal. Xanthelasma palpebrarum – a brief review. Clinical, Cosmetic and Investigational Dermatology 2018:11 1–5.

12. Rohrich RJ, Janis JE, Pownell PH. Xanthelasma palpebrarum: a review and current management principles. *Plast Reconstr Surg*. 2002;110(5):1310–1313.

13. Bolognia JL, Schaffer JV,Cerroni L. Textbook of Dermatology, 4th edn. Elsevier, (2018)Vol.2:1639-1640.

14. Christoffersen M, Frikke-Schmidt R, Schnohr P, Jensen GB, Nordestgaard BG, Tybjarg-Hansen A. Xanthelasmata, arcus corneae, and ischaemic vascular disease and death in general population: prospective cohort study. *BMJ*. 2011; 343:d5497.

15. Pathania V, Chatterjee M. Ultrapulse carbon dioxide laser ablation of xanthelasma palpebrarum: a case series. *J Cutan Aesthet Surg*. 2015; 8(1):46–49.

16.Nair PA, Patel CR, Ganjiwale JD, Diwan NG, Jivani NB. Xanthelasma palpebrarum with arcus cornea: a clinical and biochemical study. *Indian J Dermatol*. 2016; 61(3):295–300.

17.Santaella RM, Ng JD, Wilson DJ. Carbon dioxide laser-induced combustion of extravasated intraocular silicone oil in the eyelid mimicking xanthelasma. *Ophthal Plast Reconstr Surg*. 2011; 27(6):e163–e165.

18. Lee HY, Jin US, Minn KW, Park YO. Outcomes of surgical management of xanthelasma palpebrarum. *Arch Plast Surg*. 2013; 40(4):380–386.

19. Abdelkader M, Alashry SE. Argon laser versus erbium: YAG laser in the treatment of xanthelasma palpebrarum. *Saudi J Ophthalmol*. 2015; 29(2):116–120.

20. Nguyen AH, Vaudreuil AM, Huerter CJ. Systematic review of laser therapy in xanthelasma palpebrarum. *Int J Dermatol*. 2017;56:47-55.

21. Nouri K. Lasers in Dermatology and Medicine. Springer-Verlag London Limited, 2011.

22. Karsai S, Czarnecka A, Raulin C. Treatment of xanthelasma palpebrarum using a pulsed dye laser: a prospective clinical trial in 38 cases. *Dermatol Surg*. 2010;36(5):610–617.

23. Corradino B, Di Lorenzo S, Triolo A, et al. Laser treatment of giant xanthelasma palpebrarum. Lasers Med Sci 2015; 30: 2205–2207.

24. Borelli C, Kaudewitz P. Xanthelasma palpebrarum: treatment with the erbium: YAG laser. *Lasers Surg Med*. 2001; 29(3):260–264.

25. Astner S. Clinical applicability of a 1450 nm diode laser as adjunctive treatment for refractory acne. G Ital Dermatol Venereol. Italy; 2009; 144: 629–638.

26. Ichikawa K, Miyasaka M, Tanaka R, et al. Histologic evaluation of the pulsed Nd:YAG laser for laser lipolysis. Lasers Surg Med. United States; 2005; 36: 43–46.

27. Anderson RR, Farinelli W, Laubach H, et al. Selective photothermolysis of lipid-rich tissues: a free electron laser study. Lasers Surg Med. United States; 2006; 38: 913–919.

28.Karsai S, Schmitt L, Raulin C. Is Q-switched neodymium-doped yttrium aluminium garnet laser an effective approach to treat xanthelasma palpebrarum? Results from a clinical study of 76 cases. *Dermatol Surg*. 2009;35(12):1962–1969.

29. Mehmet Akdag.The effects of radiofrequency in xanthelasma of eyelid: case report. *J Int Dent Med Res*. 2013;6:128–131.

30. Ren J, Zeng LY, Chen MH. Treatment of Grade I and II types of xanthelasma palpebrarum with intralesional heparin sodium. Dermtol Ther. 2018 Nov. 31 (6):12723.

31.Wang H, Shi Y, Guan H, et al. Treatment of xanthelasma palpebrarum with intralesional Pingyangmycin. Dermtol Surg.2016 Mar.42 (3):368-76.

32. Akhyani M, Daneshpazhooh M, Jafari AK, Naraghi ZS, Farahami F,

Toosi S. Koebner phenomenon in xanthelasma after with treatment trichloroacetic acid. *Dermatol Online J*. 2006; 12(2):12.

33. Geiges ML. History of Lasers in Dermatology. Curr Probl Dermatol. 2011; 42:1–6.

34. Kabir Sardana, Vijay K Garg. LASERS in Dermatological Practice. Jaypee Brothers Medical Publishers. First Edition. (2014). Ch1:17.

35. Manstein D, Herron GS, Sink RK, Tanner H, Anderson R. Fractional photothermolysis: a new concept for cutaneous remodeling using microscopic patterns of thermal injury. *Lasers Surg Med*. 2004;34:426-438.

36.Gregory TA . Laser medicine and surgery. USA, professional medical education association . 2004:6-143.

37.Markolf H. Niemz .Biological and medical physics ,biomedical engineering Laser Tissue Inter actions Fundamentals and applications 3rd,Enlarged Edition.2007,P.1-6,201-203,248-254.

38. Krupa Shankar, et al.: Carbon dioxide laser guidelines. Journal of Cutaneous and Aesthetic Surgery 2009; 2:72-80.

39. Ben Cox. Optics in medicine. Introduction to Laser-Tissue Interactions. October 2013.

40. Hapif TP. Clinical Dermatology; a colour guide to diagnosis and therapy. Elsiever. 6th ed. (2016):e18.

41. Štulhofer Buzina D, Lipozenčić J, Bukvić Mokos Z, Čeović R, Kostović K (2010) Ablative Laser Resurfacing: Is It Still the Gold Standard for Facial Rejuvenation? Acta Dermatovenerol Croat 18:190-194.

42. Baumann L. Lasers and light devices, Cosmetic Dermatology,: McGrawHill, 2nd ed (2009): 212-220.

43. Chwalek J, Goldberg DJ (2011) Ablative skin resurfacing. Curr Probl Dermatol 42:40–47.

44. Karsai S, Czarnecka A, Jünger M, Raulin C (2010) Ablative fractional lasers (CO(2) and Er:YAG): a randomized controlled double-blind split-face trial of the treatment of peri-orbital rhytides. Lasers Surg Med 42:160–167.

45. Fife DJ, Fitzpatrick RE, Zachary CB (2009) Complications of fractional CO2 laser resurfacing: four cases. Lasers Surg Med 41:179–184.

46. Ciocon DH, Doshi D, Goldberg DJ (2011) Non-ablative lasers. Curr Probl Dermatol 42:48– 55.

47. Raulin C and Karsai S. (eds.), *Laser and IPL Technology in Dermatology and Aesthetic Medicine*, Springer-Verlag Berlin Heidelberg 2011.

48.Andreeta, M.R.B. et al: Bidimensional codes recorded on an oxide glass surface using continuous wave CO2 laser. Journal of microengineering and micromechanics.2011.

49. Shamsaldeen O, Peterson JD, Goldman MP. The adverse events of deep fractional CO2: Retrospective study of 490 patients; Laser Surg Med. Aug. 2011; 43(6):453-62.

50. Ward P.D. Baker S.R. Long term results of CO2 laser resurfacing of the face. Arch Facial Plastic Surgery.Aug 2008; 10(4):238-43.

51. Gold M.H. Fractional technology: review and clinical approaches. Clinical dermatol.oct 2007:25(5); 443-53.

52. Chajchir A, Benzaquen I. Carbon dioxide laser resurfacing with fast recovery. Aesthetic Plast Surg.2005; 29; 107-12.

53. Trelles M.A, Brychta P, Stanek J, Laser techniques associated with facial aesthetic and reparative surgery. Facial Plast Surgery. 2005:21:83-98.

54. Walia S, Alster TS. Cutaneous CO2 laser resurfacing infection rate with and without prophylactic antibiotics. Dermatol Surg 2001; 11:857-861.

55. Bogdan Allemann I, Goldberg DJ. Basics in Dermatological Laser Applications. Basel, Karger,1st edn, 2011.

56. Lynette M Brodie .Welding of skin using Nd:YAG Laser with Bipolar Contact Applicators .A dissertation submitted to University of Southern Queensland Faculty of Engineering and Surveying in 2003 .

57. Safety of laser products - Part 1: Equipment classification and requirements (2nd edn.). International Electro technical Commission. 2007.

58. Schröder K. ed. (2000). "Handbook on Industrial Laser Safety". Technical University of Vienna.

59. Omi T, Numano K. The Role of the CO2 Laser and Fractional CO2 Laser in Dermatology, *Laser Therapy 2014;* 23.1: 49-60.

60.Gaitan S,Markus R.Anesthesia in Laser Resurfacing.Seminars in plastic surgery 2012;26(3):117-24.

61. Wahlgren C.F, Quiding H. Depth of cutaneous analgesia after application of a eutectic mixture of the local anesthetics lidocaine and prilocaine (EMLA cream).*J.AM Acad* Dermatol. 2000, 42(4):584-8.

62. Goel K, Sardana K, Garg VK. A prospective study comparing ultrapulse CO2 laser and trichloroacetic acid in treatment of xanthelasma palpebrarum. J Cosmet Dermatol 2015; 14: 130–139.

63. Mourad B, Elgarhy LH, Ellakkawy H, et al. Assessment of efficacy and tolerability of different concentrations of trichloroacetic acid vs. carbon dioxide laser in treatment of xanthelasma palpebrarum. J Cosmet Dermatol 2015; 14: 209–215.

64. Delgado Navarro C, Lanuza Garc_ıa A, Llorca Carde~nosa A, et al. Application of laser CO2 for the treatment of xanthelasma palpebrarum. Arch Soc Esp Oftalmol. 2013; 88: 320–322.

65. Esmat SM, Elramly AZ, Abdel Halim DM, et al. Fractional CO2 laser is an effective therapeutic modality for xanthelasma palpebrarum. Dermatol Surg. 2014; 40: 1349–1355.

66. Roh HJ, Ryu DJ, Jung JY, et al. Treatment of xanthelasma palpebrarum by fractional carbon dioxide laser. Preliminary report. *J AmAcad Dermatol*. 2010; 62:149-155.

67. Al-Kady NA-S, Hamdino M, Abdel Kawy FAW. Fractional CO2 laser versus trichloroacetic acid 50% for xanthelasma palpebrarum therapy. *J Cosmet Dermatol*. 2020 ; 00:1–6.

68. Dan Li, Shi-Bin Lin, and Biao Cheng. CO2 Laser Treatment of Xanthelasma Palpebrarum in Skin Types III-IV: Efficacy and Complications after 9-Month Follow-Up. Photo bio modulation, Photo medicine, and Laser Surgery 2019; 37(4): 244–247.

الخلاصة

خلفية الدراسة:اللوحية الصفراء للجفون عبارة عن رواسب صفراء محددة الحواف من الكوليسترول تحت الجلد ، وعادة ما تحدث على الجفون أو حولها. هي مصدر قلق تجميلي شائع. على الرغم من وجود مجموعة واسعة من الأساليب العلاجية لـ اللوحية الصفراء للجفون ، إلا أنه لا يوجد إجماع عام على العلاج الأمثل لمثل هذه الحالة.

الهدف من الدراسة: تقييم فعالية وسلامة ليزر ثاني اوكسيد الكربون الجزئي في علاج اللوحية الصفراء للجفون.

المرضى وطرق الدراسة: اجريت هذه الدراسة التداخلية العلاجية في عيادة وحدة الليزر التابعة لمركز الامراض الجلدية والتناسلية في مدينة الطب/بغداد،للفترة من بداية شهرتشرين الاول٢٠٢٠ ولغاية نهاية شهرشباط ٢٠٢١. تضمنت هذه الدراسة ١٠ مرضى بالغين(ثمان نساء ورجلين) يعانون من آفات اللوحية الصفراءللجفون وتراوحت أعمارهم بين ٣٥-٥٠ سنة (متوسط =٤٣ سنة). العلاج كان بجلسة واحدة أو حتى ٣ جلسات ليزر ثاني أوكسيد الكربون الجزئي (١٠,٦٠٠نانومتر) بفواصل زمنية من ٢ إلى ٤ أسابيع. تم تقييم جميع المرضى باستخدام التصوير الرقمي والمراقبة السريرية.

النتائج: تمت إزالة آفات اللوحية الصفراء للجفون على كلا الجانبين لجميع المرضى بنجاح مع تحسن كبير في الحجم واللون والسمك. كانت فترة الشفاء قصيرة ودرجة رضا المريض ممتازة بشكل ملحوظ للآفات التي تم علاجها باستخدام ليزر ثاني أوكسيد الكربون الجزئي. خلال فترة الدراسة لم تظهر اي مضاعفات و لم يتم الإبلاغ عن تندب اوتكرار.

الاستنتاج: ليزر ثاني أوكسيد الكربون الجزئي هو خيار علاجي فعال وآمن لـ اللوحية الصفراء للجفون مع فترة شفاء قصيرة بشكل ملحوظ ،درجة رضا مرتفعة للمرضى ، جلسات قليلة ، ومضاعفات خفيفة.

وزارة التعليم العالي والبحث العلمي

جامعة بغداد

معهد الليزر للدراسات العليا

استعمال ليزر ثاني اوكسيد الكربون الجزئي في علاج اللوحية الصفراء للجفون

دراسة مقدمة الى معهد الليزر للدراسات العليا /جامعة بغداد /كجزء من متطلبات نيل درجة الدبلوم العالي ليزر في الطب/الجلدية

من قبل

علي سلمان شمخي

زميل المجلس العراقي للاختصاصات الطبية/جلدية وتناسلية

بكالوريوس طب وجراحةعامه

بإشراف

الدكتور الأستشاري

علي فاضل السعدي

زميل المجلس العراقي للاختصاصات الطبية/جلدية وتناسلية

دبلوم عالي/ تطبيقات الليزر في الطب

١٤٤٢ هجرية   ٢٠٢١ميلادية