DISSERTATION ON THE EFFECT OF CARBON DIOXIDE LASER IN BENIGN SKIN CONDITIONS

DISSERTATION SUBMITTED TO STANLEY MEDICAL COLLEGE, CHENNAI FOR

MD (Dermatology, Venereology and Leprology)

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CHENNAI - TAMILNADU

CERTIFICATE

This is to certify that this dissertation entitled **"Dissertation on the effect of Carbon dioxide Laser in benign Skin Conditions"** is the bonafide original work of **Dr. G.Senthil,** in partial fulfillment of the requirement for **MD (Branch XII) Dermatology, Venereology and Leprology** examination of the Tamil Nadu Dr. MGR Medical University to be held in March 2007.

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DECLARATION

I, **Dr. G. Senthil,** solemnly declare that dissertation titled, **"Dissertation on the effect of Carbon dioxide Laser in benign Skin Conditions "** is the bonafide work done by me at Govt. Stanley Medical College and Hospital during the period August 2004 to September 2006 under the expert guidance and supervision of **Prof.A.M. Jayaraaman M.D., D.D., Head of the Department,** Department of Dermatology.

The dissertation is submitted to the **Tamil Nadu Dr. MGR Medical University** towards partial fulfilment of requirement for the award of **MD Degree (Branch XII) in Dermatology, Venereology and Leprology.**

Place : Chennai

Date : **Dr.G. Senthil**

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CONTENTS

INTRODUCTION

As there are about 5-10% of all skin diseases amount to benign skin lesions and other cosmetically disabling conditions, amenable to laser therapy, it is decided to find out the effect of CO2 laser in the treatment from the patient's point of view regarding better look cosmetically and psychologically.

AIM AND OBJECTIVES OF THE STUDY

1. To asses the effect of CO_2 Laser in benign skin conditions.

2. To observe the side-effects of CO_2 Laser while and after treatment.

3.

REVIEW OF LITERATURE

Laser has become an essential tool for dermatologic surgeons. Conditions that until very recently could not be successfully treated with an acceptable risk-benefit ratio can now be easily treated in the office setting by using one of an ever-expanding array of lasers.

HISTORY: [1, 3]

The theoretical concept of laser light production was first proposed by Albert Einstein in 1916[1]. The first stimulated emission of radiation in the microwave portion of the electromagnetic spectrum, known as **MASER**, for ***M***icrowave ***A***mplification by the ***S***timulated ***E***mission of ***R***adiation, was achieved by Townes and Gordon in 1954[1].The first functional laser (Light Amplification by Stimulated Emission of Radiation) system was Ruby laser developed by Maiman in 1960[1].The first laser to be used in humans was a Ruby laser studied by Leon Goldman for removing tattoos in early 1960s[1].Subsequently Nd-YAG laser in 1961,the Argon laser in 1962 and the Co2 laser in 1964 were introduced.

The argon laser was first used to treat vascular lesions during the mid 1970s [5] but was limited by the high risk of scarring .It was only in 1983 [5], with the publication of the theory of Selective Photothermolysis, that a further understanding of laser-tissue interactions was possible.

Laser Light Properties: [1, 4]

"Light amplification stimulated emission of radiation" describes the mechanism by which a laser produces tremendously bright light and is made possible by quantum mechanics of matter. Atoms are composed of a nucleus with electrons orbiting around it .The electrons are usually in an orbit as close as possible to the nucleus , which is in their Resting or Ground state. If the electron absorbs a photon of light (Fig.1), it

moves into a higher, more energetic orbit that matches the energy absorbed from the photon. This more energetic or excited electron is relatively unstable ,and the electron falls back down spontaneously to its resting state orbit while emitting a photon of light with the same energy that it had originally absorbed ,thus maintaining energy conservation. This process represents spontaneous emission of radiation (Fig.2)and is seen in fluorescence and phosphofluorescence phenomena.

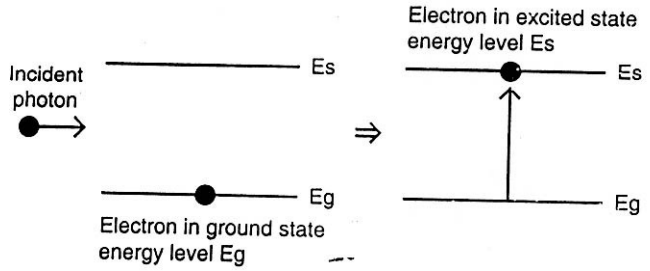

Fig.1. Absorption.

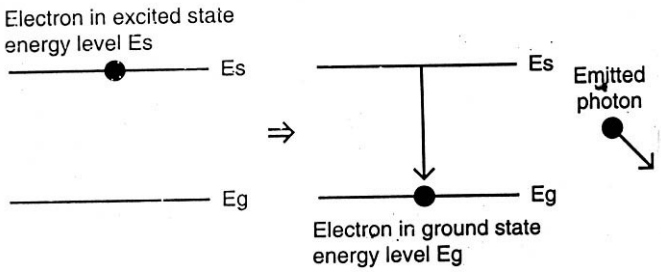

Fig.2. Spontaneous emission.

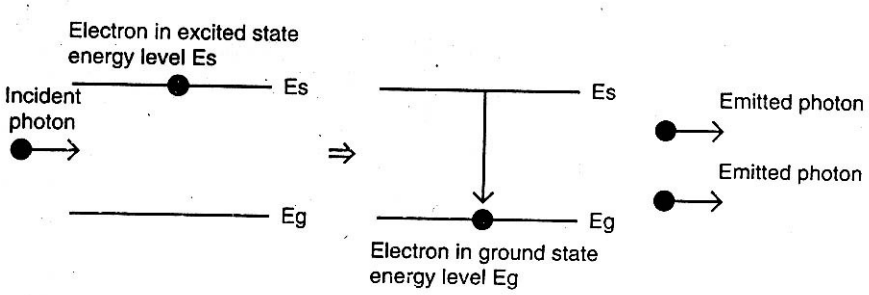

Fig.3. Stimulated emission.

Stimulated emission of radiation (Fig.3) occurs when a electron already in an excited state absorbs a photon of light and emits two photons of light while returning to the resting state orbit. The emitted photons match the absorbed photon in wavelength, phase and direction. The electron was originally raised to an excited state by pumping energy into the laser cavity. The energy for emission of two photons come from the difference in energy between the excited and resting state of the electron plus the energy of the photon that the electron just absorbed. This maintains energy conservation while doubling the number of photons in the laser cavity. This process is repeated many times in the laser cavity to create a very bright laser beam. Normally the population of electrons is such that most of the electrons reside in the resting state, when the majority of electrons in the laser cavity are raised to higher orbits by absorbing energy, the population is said to be inverted. The process of stimulated emission doesn't produce a very sufficient or even noticeable amplification unless a population inversion occurs.

Stimulated emission of radiation is distinct from conventional light by following ways:

1) MONOCHROMATICITY:[1]

Monochromatic radiation is radiation of single wavelength. All of the light is of a single ,discrete wavelength or more precisely, the light is of a narrow wavelength band in

a Gaussian distribution around the characteristic wavelength of the laser. The wavelength is determined solely by the laser medium.

2)COHERENCE: [1, 5]

Light can be considered as a sine wave. The laser is temporally and spatially coherent. (i.e) The light waves are in phase both in time and space. The light waves are perfectly aligned in laser light so that each peak exactly matches both in time and space and each trough likewise matches up with every trough. The property is important for beam handling, shaping,focusing and coupling into optical fibres.

3)COLLIMATION (Fig.4): [1, 4, 5]

It refers to the nondivergent and energy conserving properties of light in which the waves are parallel. This is the direct result of temporal and spatial coherence. A collimated beam has the same spot size, no matter how far away or close to the skin one holds the laser handpiece. Most lasers use a focusing lens in the handpiece. This means that the spot size varies depending on how far away from or close to the skin one holds the handpiece.

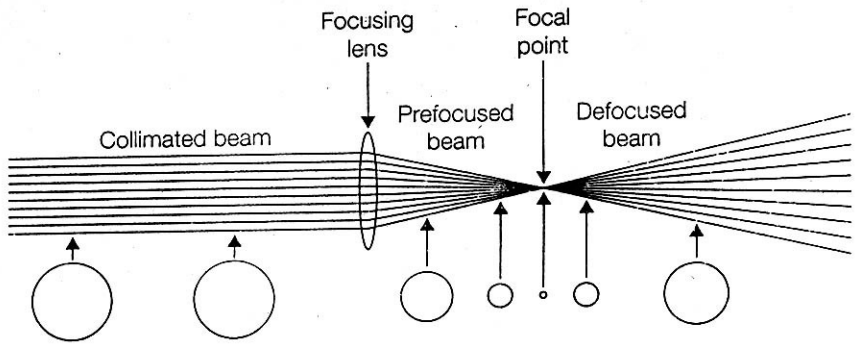

Fig.4. Collimated beam of light

THE PRACTICAL LASER (Fig.5): [4]

All Practical lasers can be divided into four major sections:

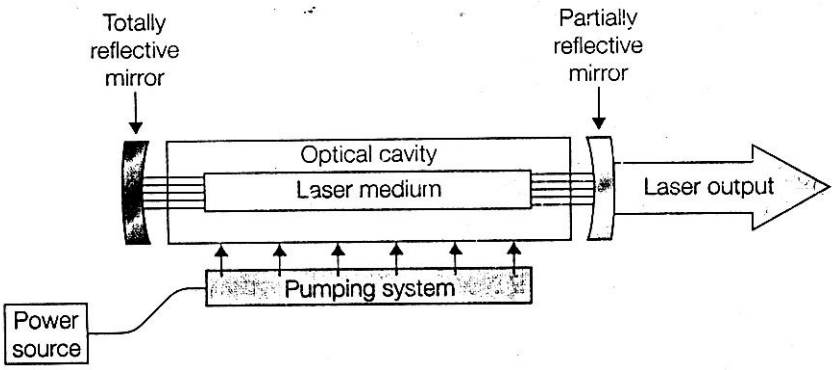

Fig.5. Schematic drawing of a generic laser system

1)LASING MEDIUM (Active medium ,Gain medium)**:**

Lasing medium represents the heart of the laser system and lasers are named according to their lasing Medium. It supplies the electrons needed for stimulated emission of radiation and determines the wavelength of the radiation produced. The lasing medium can be gaseous [Argon, CO2, He-Ne, Copper Vapour, Copper Bromide, Excimer or Krypton] , liquid [Tunable dye, Rhodamine], solid [Alexandrite, Erbium:yttrium-aluminium-garnet (Er:YAG) , Neodymium:yttrium-aluminium-garnet (Nd-YAG), Ruby or Diode] or free elcetrons.

2) OPTICAL RESONANCE CAVITY:

It encloses the laser medium and contains the amplification or excitation process. It may be manufactured of metal or ceramic and typically has mirrors at either end. They are aligned precisely so that their axis are parallel and are along the axis of the laser medium. One of the surfaces is 100% reflective but the other is only 90-95% reflective. These mirrors (plane or curved) serve to reflect the photons from the excited atoms back and forth many times between the opposite ends of the tube , resulting in amplification. It

is through partially reflective surface that the laser energy emerges as the laser beam, which is referred to as output coupling. Thus it provides positive feedback amplification.

3) PUMPING SYSTEMS:

It supplies energy to the lasing material to create and maintain a population inversion within it. The mechanism of energy transfer is chosen and tailored to suit the particular laser. Efficiency of pumping system is usually low,varying from a fraction of a percentage in most systems upto 30% in a few cases. Primarily because of such inefficiency ,cooling systems and large supplies are necessary and are incorporated in many systems.

Common pump sources include optical devices, flashlamps, other lasers(Argon,N2,Excimer,Xenon fluoride) and electrical discharges, direct current excitation and radiofrequency. Most optical pumping involves the use of a flashlamps. Electrical pumping is probably the most common of the pumpings used in medical systems.

4) LASER BEAM DELIVERY DEVICES:

Three systems are currently being used to deliver laser light from the optical cavity to the tissue:

a) An articulated arm involves the use of rigid tubes with reflective mirrors at each connecting end.

b) Fibroptics are fibres consisting mainly of quartz and are used to transmit light.

c) Manual control of laser light delivery is subjective and can be inaccurate even in experience hands. Micromanipulator improves the accuracy of laser light delivery and

can be connected to the fibre optics or the articulated arm through a microscope. Automatic scanning devices involve the use of computer-controlled micromanipulator that deliver laser light in a controlled manner. Most lasers in current use use noncontact handpieces; that is, only the laser beam itself is allowed to interact directly with the tissue. In noncontact systems, the handpiece contains only a converging lens system (focusing the beam to one or more spot sizes at the operating distance) and a pointing guide which aids the surgeons in controlling the distance between the handpiece and the target tissue.

LASER PHYISCS [1, 3, 4, 6]

The interaction of laser energy with the tissue depends on a number of factors namely power, spot size, duration of exposure, wavelength and tissue properties.

1. Energy:

Light is measured in fundamental energy units called **Joules.**

2. Power:

It is the rate of energy delivery measured in Watts. **1Watts ==1joules/Sec**

3. Fluence or Energy density:

It is the actual amount of energy applied to the unit area of target tissue and depends the exposure time. It reflects the total energy delivered to the tissue which is directly related to the volume of tissue that will be treated.

Fluence (Joules/Cm2) == Power x Exposure time (Sec)/Area (Cm2)

As the energy fluence increases, tissue coagulation increases as well.

4. Irradiance or Power density:

It is rate of energy delivery (Power) per unit area to an object. Low irradiance results in coagulation. Higher irradiance results in tissue vaporization. It is independent of pulse duration. Therefore it is usually used when referring to continuous-wave lasers such as CO2 laser, since there is no fixed pulse duration.

Irradiance == Watts / Spot size (cm2)

5. Cross-Sectional Power density:

It is an average power over the cross-sectional area of the laser beam that is taken to be uniform. It is made up of tranverse electric modes (TEMs). TEM is the distribution of energy across the laser beam diameter. The types of TEM are TEMoo (the lowest order mode used , the energy distribution follows a Bell shape in which the peak power density is at the centre of the beam) and TEMo1 (Energy distribution has a Doughnut shape with a cold spot in the centre; this is less suitable for incisional work).

6. TEMPORAL MODES OF OUTPUT:

Laser operate in either a pulsed, continuous or quasi-continuous mode.

PULSED MODE:

Pulsed lasers deliver their energy in a single discrete pulse or a train of pulses. Frequency refers to the number of pulses delivered in one second ,and pulse width or pulse duration is the length of the pulse in seconds. In general, a pulsed lasers produces more intense energy and less adjacent tissue damage than continuous lasers. This is because the tissue is allowed to cool in between pulses. It has been shown that if laser irradiatioin is repeated before the tissue completely cools, the temperature elevation is additive. This inadvertent energy increases the likelihood that heat can extend beyond the target into the surrounding structures.

CONTINUOUS MODE:

It produces a steady emission with little fluctuation. In other words , this type of laser emits a beam as soon as the foot pedal is depressed and then continues to lase until the foot pedal is released.

QUASI-CONTINUOUS:

Quasi-continuous lasers emit true pulses, but their duration is in nanoseconds with rates as high as 15,000/s.This results in ”machine gun” type of pulse delivery, which is so rapid that the tissues responds as if it were a continuous wave.

SKIN OPTICS [1, 5, 6]

Skin optics constantly changing with changes in pigmentation , hydration , age , body site and genetic background. Light can interact with skin in the following ways (Fig.6).

1. REFLECTION: [6]

About 5-7% of incident light at all wavelengths is reflected from the stratum corneum air interface without any clinical effect.

2. ABSORPTION:

In the epidermis and stratum corneum, radiation wavelengths below 300 nm is absorbed rather than reflected. When electromagnetic radiation encounters skin, photons are absorbed by individual molecules, called chromophores.

CHROMOPHORES [1, 5]	***ABSORPTION WAVELENGTH***
Protein, Urocanic acid, Melanin, Nucleic acid	UV C and B range (<320 nm)
Melanin	320—1,000 nm
Water	>1,000 nm
Oxyhaemoglobin, Deoxyhaemoglobin	UVA, Blue, Green, Yellow light
Collagen	Visible and Near-infrared regions

Radiation with wavelengths greater than 300 nm have a greater degree of penetration and can therefore reach the dermis. The term “Optical window” [5] refers to the ability of radiation to penetrate deep into skin tissue because of low absorption and low scattering. This applies to radiation of wavelengths between 600—1,300 nm. Melanin is the main chromophore at this spectrum.

3. SCATTERING: [1, 5]

It is largely due to collagen in the dermis.

Objects wavelength	***Scattering***
Smaller than that of light	Rayleigh scattering (relatively weak)
Matcthing the incident light	Forward-directed (inversely with the wavelength)
Greater than that of light	Highly forwarded –directed (independent of wavelength)

4. TRANSMISSION: [5]

Residual light is transmitted to Subcutaneous tissue . This is largely dependent on wavelength.

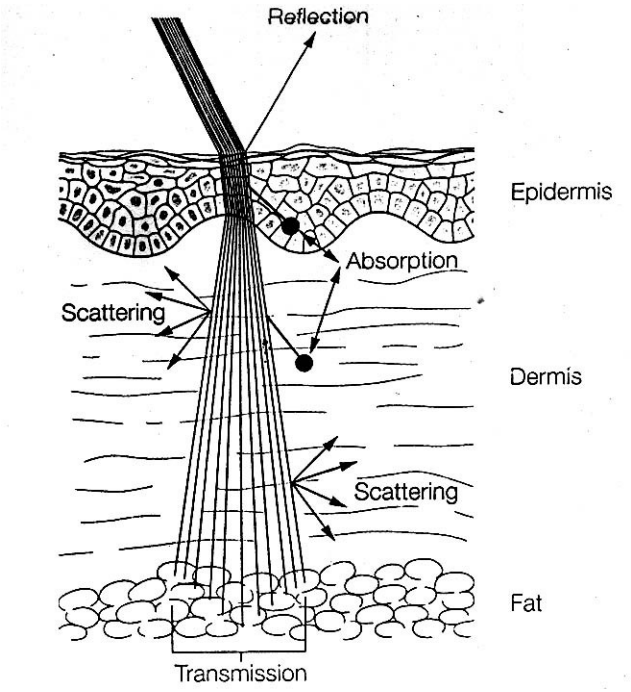

Fig.6. Fate of incident light on skin.

LASER --- TISSUE INTERACTION

1. Photothermolytic effect: [3]

Photothermal interactions, are derived directly from heat generated by laser.

TEMPERATURE	***TISSUE DAMAGE***
Below 50°C	Reversible
50—100°C	Irreversible
Above 100°C	Vaporization

Extent of tissue damage is directly proportional to the amount of heat dissipated from the target site to the surrounding tissue. It depends upon the rate of heating determined by power density and exposure time.

2. Photomechanical effect:[6]

Here, High energy-level pulse laser disperses the target tissue by rapid thermal expansion and Local vaporization. Eg. Q-Switched ruby laser for removal of tattoo.

3. Photoacoustic effect:[3]

The high-energy rapidly pulsed laser mechanically fragment and shatter the pigmented chromophore or particles. The smaller fragments are cleared away by the body lymphatics , Vasculature etc.

4. Photochemistry:[3]

This principle is utilized for photodynamic therapy. This involves the use of laser, in conjunction with a topical or systemic photosensitizer , in producing the beneficial effects.

5. Selective photothermolysis:[1]

To achieve selective photothermolysis, the exposure to laser energy must be less than or equal to the thermal relaxation time of the target chromophore. Thermal relaxation time[7] is the time needed for an object to dissipate about two-thirds of its absorbed heat. It is related to shape and size of target. For most chromophore in the skin, the thermal relaxation time is proportional to the square of the object's diameter. Since large objects lose heat more slowly than small objects do, larger chromophores will have longer thermal relaxation times.

Thermal relaxation time of laser targets:[7]

	Diameter (µm)	***Thermal relaxation time (tr)***
EPIDERMIS	**60**	**2 m sec**
BASAL LAYER	**20**	**400 µsec**
MELANOSOME	**1**	**0.2 µsec**

MICROVESSELS	**20** **50** **100**	**140 µsec** **1.2 m sec** **3.6 m sec**
ERYTHROCYTES	**5**	**5 µsec**
HAIR BULGE	**>100**	**2 m sec**

6. SKIN COOLING: [5, 6]

Skin cooling before, during and after a laser pulse helps to protect the epidermis and superficial dermis from thermal injury and to reduce pain and swelling. Cooling may take three forms.

a) Cold air convection:

Air, chilled to temperatures as low as -30°C, is directed onto the area to be treated.

b) Contact cooling:

This may involve simple application of ice-packs or sophisticated systems which pass chilled water between colorless and transparent plates which are usually sapphire as it is a far more efficient conductor than glass.

C) Cryogen spray (dynamic) cooling:

A frozen gas sprayed onto the skin immediately below the laser pulse. Evaporative cooling has a high heat transfer coefficient and this is therefore the most efficient way of precooling.

TYPES OF LASERS [2, 8]

TYPE	LASER	WAVELENGTH (nm)	MODE OF EMISSION	LASING MEDIUM	DEPTH OF PENETRATION	CHROMOPHORES

					N	
Visible 400-700 nm	***Argon***	488- 514	CW	Argon gas	1-2 mm	Hemoglobin, Melanin
	Dye	577-585 (pulsed) 570-630 (Tunable)	Q-switch	Copper Rhodamine -G	1-2 mm	Melanin, Tattoos, Hemoglobin
	Ruby	694	Q-Switch	Ruby Crystal	1mm	Melanin, Tattoos
	Alexandrite	755	Q-switch	Alexandrite crystals	1.5mm	Tattoos , Melanin
	Krypton	521, 530, 568	CW	Krypton Gas		Hemoglobin, Melanin
	Copper	511, 578 532	Pulsed Q-switch	Crystals	1.6mm	Hemoglobin, Melanin, Tattoos (Red)
	Nd-YAG					
Near infrared	***Diode***	810	CW,Pulsed	Crystals	4mm	Melanin Hemoglobin

	Nd-YAG	1064	CW, Q-Switch	Crystals	5mm	Melanin, Tattoos, Hemoglobin
Mid infrared	**Er-YAG**	2940	CW, Q-Switch	Crystals	0.03mm per pass	Water
Far infrared	***CO2***	10,600	CW, SP	1part CO2,1.5 parts N2, 4 parts Helium	0.1mm per pass	Water

LASERS FOR TREATING PIGMENTED LESIONS[8]

LASER	**WAVELENGTH(nm)**	**LOCATION OF TARGETED PIGMENT**
Flashlamp pumped PDL	504, 510	Epidermis, Superficial Dermis
QSNd-YAg	532	Epidermis, Superficial Dermis
QS Ruby (QSR)	694	Epidermis, Dermis
QS Alexandrite	755	Epidermis, Dermis

QS Nd-YAG	1064	Deep Dermis
Long-pulsed Ruby	694	Dermis (Larger targets)
Long pulsed Alexandrite	755	Dermis (Larger targets)

LESION	***LASER OF CHOICE***
Café-au-lait	***Pulsed dye laser***
Small congenital nevi ***Nevus spilus, Nevus of Ota or Ito,*** ***Tattoos***	***Long-pulsed ruby*** ***Q-switched ruby laser***
Lentigines	***QS Nd-YAG***
Becker's nevus	***Long-pulsed ruby laser***

LASERS FOR TREATING VASCULAR LESIONS [5, 6, 8, 9, 10]

ARGON LASER	First laser used for the treatment of Portwine Stain and remained the treatment of choice until the late 1980s.
KRYPTON LASER	Facial telangiectasia and leg veins
COPPER VAPOUR LASER	Portwine stain
FLASHLAMP-PUMPED PULSED DYE LASER (Treament of choice)	Portwine stain, hemangioma, Telangiectasia, arborizing leg veins

LASERS FOR HAIR REMOVAL [8]

1. Nd-YAG laser

2. Long-pulsed ruby laser

3 Alexandrite laser

4. Diode laser

5. Intense xenon flashlamp

LASERS FOR TATTOO REMOVAL[8]

COLOR OF TATTOO	**OPTIMAL LASER**	**ALTERNATIVE**

		LASER
BLUE-BLACK	***Q-switched ruby Laser***	Q-switched alexandrite QS Nd-YAG
GREEN	***Q-switched alexandrite***	Q-switched ruby, QS Nd-YAG
RED, ORANGE, YELLOW	***Pulsed dye laser***	QS Nd-YAG

COMPLICATIONS AND HAZARDS OF LASER:[13]

POSSIBLE COMPLICATIONS OF LASER THERAPY:

1) Immediate Erythema, oedema, pain, exudation, purpura

2) Secondary infection

3) Pigmentary changes: Hyperpigmentation, hypopigmentation

4) Textural changes, atrophy

5) Scarring, keloid

POTENTIAL HAZARDS TO LASER MEDICINE:

1) Hazard to eye === Retina, especially macula: Permanent visual loss

[Suitable protective eye goggles, eye-shields]

2) Hazard to skin === severe burns and scarring

[Avoid by training and experience]

3) Electrical hazard === High voltage: Life threatening

[Strictly follow the safety precautions]

4) Hazards from Fumes and vaporized tissues== Mutagenic and carcinogenic

Exacerbate asthma and emphysema

Infectious risk (Staph.aureus and neisseria)

HPV, HIV

[Fume evacuator, good ventilation, mask]

PRECAUTIONS IN LASER THERAPY:[13]

1) ALWAYS wear safety goggles with recommended filters whenever the laser in use.

2) ALWAYS lock the door of the room during treatment.

3) NEVER look directly into the laser beam; or at scattered or reflected laser light.

4) NEVER point the laser handpiece at any person except at the treated area.

5) NEVER remove any covers from the cabinet of the machine and attempt to repair.

6) NEVER use the laser in the presenc of flammable anaesthetics.

7) NEVER step on or abruptly bend the fibre-optic cable.

8) NEVER move the laser machine during operation or within 30 minutes of turning off.

9) DO NOT turn off the machine immediately after treatment.

10) DO NOT turn off the main electrical switch.

BEFORE TREATMENT:[13]

i) Turn on the laser machine for warm up

ii) Written consent after explanation of the procedures

iii) Take Clinical Photographs

iv) Ensure the patient having eye-protection

v) Prepare local anaesthetics if necessary

Lignocaine (without adrenaline)

vi) Lock the door and turn on the warning lamp.

DURING TREATMENT:[13]

i) Ensure that the patient has eye-protection all the time

ii) Measure the treatment time

iii) Plume suction if necessary

AFTER TREATMENT:[13]

i) Apply antiseptic cream or emollient for the patient

ii) In between treatment, keep the machine at standby.

iii) After treatment for all patients, wait for sometime before turn off the machine

AFTER CARE FOLLOWING LASER TREATMENT:[13]

i) Expect a sunburn - like reaction with possible blistering within the first 24-48 hrs. Pain is usually minimal and can be relieved with either analgesics and / or cool soaks with a wash cloth.

ii) A crust or scab may occur and should last for 7-14 days. Don't pick off the scab.

iii) Keep the area clean and dry until the scab / crust falls off. Wash gently with Soap and water and apply a thin layer of moisturizer or antibiotic ointment.

iv) Once the scab / crust has come off the area may look pink and even slightly depressed or indented. Both the pinkness and depression should improve over the next several weeks to months.

v)Avoid direct sunlight or sun exposure to the treated area for 3-6 months. Use at least an SPF of 15 or greater sunscreen, or wear a hat or other protective clothing. Be aware that unprotected sun exposure can result in an uneven repigmentation, producing brown spots that can take months to fade away and in rare cases may be permanent.

vi)Be patient - It may take up to three months to adequately judge the true response of condition subjected to treatment.

CARBON DIOXIDE LASER

The CO2 laser was once called workhorse[1] of lasers in dermatology.

EVOLUTION OF CO2 LASER IN DERMATOLOGY:

CO2 Laser was first developed by Patel at Bell in 1964[11] and is used most frequently in modern dermatology. Ultrapulse CO2 and flashscan CO2 were used in 1985. .The CO2 laser was first developed as a continuous beam surgical cutting tool. Focused to a spot size of 0.1 to 0.2 mm, this laser generates irradiances of 50 to 100,000 w/cm^2. Defocussed to a larger spot size and lower tissue energy density, the CO2 laser was used as an ablative tool to vaporize cutaneous lesions. Cutting with CO2 laser is relatively bloodless and has been thought by some to reduce the severity of postoperative pain by destroying sensory nerve endings. The use of the CW CO2 laser as a cutting instrument is limited by the unwanted damage to adjacent tissues.

Super pulsed lasers with higher peak power at a rapid pulse train of 250 to 1000 Hz showed early promise, but after more detailed evaluation have not shown to produce more precise tissue cutting or a significant reduction in the zone of thermal injury. There has been a recent surge of interest in the use for skin resurfacing.

PROPERTIES OF CO2 LASER[11]

LASING MEDIUM	Mixture 1 part CO2:1.5 parts Nitrogen:4 parts Helium gases
PUMP	Direct electric current Radiofrequency

EFFICIENCY	10-15 %
ELECTROMAGNETIC SPECTRUM	Far Infrared, Invisible, 10,600nm
DELIVERY	Mirrored articulating joints
ABSORPTION	Intracellular and extra cellular water
DEPTH OF PENETRATION	0.1 mm of soft tissue
EXTINCTION COEFFICIENT	0.1 mm of water
SCATTER IN TISSUE	Minimal

CO2 LASER OFFERS SEVERAL UNIQUE SURGICAL PROPERTIES [12]

1) Disease volumes are vaporized under precise visual control

2) There need be little mechanical contact with the intended target.

3) Heat propagation to adjacent tissue is minimal.

4) Microorganisms at the impact site are automatically destroyed.

5) Vessels smaller than 0.5 mm in diameter (arterioles) are thermally sealed.

SIX PHYSICAL PRINCIPLES UNDERLYING SURGICAL EXPERTISE [12]

I. Parameters concerned with minimizing thermal diffusion

1) Use rapid super pulse or chopped wave, rather than continuous wave ,thus preventing thermal relaxation between pulses.

2) Minimize duration of thermal diffusion , by using high power settings.

3) Avoid carbonization of the impact crater , by keeping power density >750 W/Cm2,wping away debris , performing ablations with the operating microscope, and not caramelizing extravasated blood.

II. Parameters influencing surgical control

4) Tailor pulse fluence or average power density to individual hand-eye speed.

5) Control beam geometry by incremental focus-defocus of the microslad, using tightly focused spots for incision and rounded beams for ablation.

6) Maintain high power in delicate situations, using shuttered pulses to maintain surgical control.

The incident beam of the CO2 laser arises from an activated medium containing CO2, N2 & Helium in the respective ratio of 1:1.5:4[11].It has a characteristic wavelength of 10,600nm and falls into the far infrared region. 97%[11] of its energy is absorbed at its impact site in skin, and 98%[11] is absorbed in water at a depth of 0.1-0.2.mm.Thus even the 3% of energy reflected in skin is absorbed totally after passing through a very short distance in adjacent tissue, the majority of which is water. The end result is a relatively small amount of thermal damage to tissue not in direct contact with the CO2 beam. In skin, the thermal damage extends for only 30-50μ from the impact site. The impact site on the other hand, receives virtually the total power output of the CO2 laser, resulting in the instantaneous transformation of tissue water to steam and thus, Vaporization or Evaporation.

The Clinical effect[11] depends upon power, area of impact site and time of Exposure. Increase the power and time of exposure result in an increase in thermal

damage. Basically, the almost parallel beam arising from the plasma tube is delivered to an articulating hand piece through a system of perfectly aligned mirrors. Before exciting the hand piece, the beam must pass through a lens, which causes the beam to be focused at a distance from the lens equal to its focal length. At this point, the beam is its smallest and power density is most concentrated. In this focused mode it can be used for excision.[11] By increasing the target to hand piece distance, the beam becomes defocused. In this mode, it can be used for tissue Vaporization.[11]

CLINICAL APPLICATIONS OF THE CARBON DIOXIDE LASER

I. VAPORIZATION MODE (DEFOCUSED)[11]

TUMOROUS CONDITIONS

Angiofibroma

Syringoma

Trichoepithelioma

Neurofibroma

Actinic cheilitis

Superficial basal cell carcinoma

VASCULAR CONDITIONS

Lymphangioma circumscriptum

Angiokeratoma

Port wine stain

Cherry angioma

Pyogenic granuloma

PROLIFERATIVE DISORDERS

Epidermal nevus

Xanthelasma

Verruca

Steatocystoma

Digital mucous cyst

Nodular amyloidosis

MISCELLANEOUS CONDITIONS

Decorative tattoo

Traumatic tattoo

Balanitis xerotica obliterans

Granuloma faciale

Revision of grafts or flaps

II. EXCISIONAL MODE (FOCUSED)[11]

Rhinophyma

Keloid

Refractory localised type

Acne keloidalis nuchae

Earlobe

Bloodless surgery

Highly vascular tissue

Patients on anticoagulant therapy

Treatment of cutaneous malignancies

Mohs' surgery

Excision of stromal independent neoplasms

Squamous cell carcinoma

Melanoma

Perforation of exposed cranial bone

Patients with pacemakers that restrict electrosurgical instrumentation.

CO2 LASER IS POTENTIALLY THE TREATMENT OF CHOICE[13]

Epidermal nevus

Cutaneous resurfacing procedures

Actinic cheilitis

Bowenoid papulosis

Rhinophyma

Sublingual keratosis

CO2 LASER MAY OFFER BETTER RESULTS OR FACILITATE THE PROCEDURE[13]

TUMOURS:

Angiofibroma

Syringoma

Trichoepithelioma

Neurofibroma

Seborrheic keratosis

Xanthelasma

Superficial basal cell carcinoma

Squamous cell carcinoma in- situ

INFECTIONS:

Extensive or large condyloma acuminatum

Verruca vulgaris

Recalcitrant wart

Cuaneous infection such as leishmaniasis

Debridement of burns or infected ulcer

VASCULAR:

Lymphangioma circumsriptum

Angiokeratoma

Pyogenic granuloma

Cherry angioma

Granuloma faciale

OTHERS:

Cosmetic excisional surgery

Ingrowing toe nails

Lichen planus of the penis

Hailey-Hailey disease

Chondrodermatitis nodularis helica chronicus

Oral florid papillomatosis

Blepharoplasty

Hair transplant

LESIONS THAT BETTER RESULTS CAN NOW ACHIEVED USING NEW LASERS[13]

Café-au-lait spots

Ephelides

Lentigines

Port wine stain

Tattoo

Telangiectasia

PRE OPERATIVE CONSIDERATIONS [2]

PLANNING:

Determine the type of procedure (Ablative Vs Incisional)

Select the appropriate anesthesia (And Sedation , if necessary)

Make the patient aware of what to expect postoperatively (Pain, restriction of activities and wound care)

Ensure all equipment is in proper working conditions

Make postoperative dressing material is at hand

SAFETY:

Ensure the safety of the patient, surgical staff and any observers, with laser both in and out of hand.

Laser safety equipments

Proper smoke evacuation equipment

Laser -approved surgical masks

Protective eyewear for all

Accessible water supply and wet drapping.

SETTING:

Appropriate settings vary from surgeon to surgeon. Changes in power being delivered to a target can be adjusted by actually adjusting the laser output or by changing the impact spot size.

SPOT SIZE:

Hand pieces are available that allow for delivery of a variety of spot sizes. Perhaps the most common are those that allow for delivery of impact spots of 1.0mm and 2.0mm.Understand that the impact spot printed on the handpiece is only for that handpiece and only when it is held at the focal distance that is appropriate for the lens in that handoiece. This is usually accomplished safely, accurately and successfully with the use of stylus of appropriate length that can be fitted to the end of the bore of the handpiece. The beam exciting from a CO2 laser is not parallel but divergent, and withdrawing the hand piece from the appropriate focal distance increases the size of the impact spot. (Moving the hand piece closer than the focal length has a similar effect, as well as the added effect of overshoot). Although this can be very effective way of performing ablative procedures, it does require skill and experience and is best learned under the watchful eye of a preceptor. On the other hand , incisional procedures are less forgiving and require the hand piece to be held at the appropriate distance for reasonable, safe, and chare-free cutting. Hand pieces are available with cutting spot sizes of 0.1mm. The most common incisional hand pieces , however, have 0.2mm spot sizes. Although it

may seem a minor difference, consider that the power required to cut with a 0.2mm impact spot in the same manner as with a 0.1mm spot is higher by a factor of four than with the 0.1mm spot.

TECHNIQUE:[2]

INCISION:

Appropriate prepare, drape and anesthetize the patient. Draw the intended incision or excision with a surgical marking pen. Make sure the laser is set appropriately. Drape the immediate surgical fields with wet sterile sponges or towels. Bring the smoke evacuation system to the field prepared to remove vapour during procedure. Reasonable starting parameters should be 5 to 10W for a 0.1mm spot or 10 to 20W for 0.2mm spot. Use a stylus to gauge the appropriate distance at which the hand pieces should be held from the target. Make an incision along the tongue depressor as a final check of power, spot, distance, alignment of aiming and working beams, and hand stability. Then the aiming beam should be on or slightly inside the proposed incision line. Begin with a brief impact and check the effect .If all settings and angles are appropriate, begin with incisional pass.

After the first pass, asses the wound. If the incisional pass is of acceptable depth, it would be appropriate to increase the power output to the laser for maximum efficiency. Continue the next pass, and keep blood or melted fat from the field. If the areas shows bleeding, apply pressure with gauze sponges slowly, but with continued downward pressure. Immediately withdraw the hand piece several inches from the site, and with aiming beam pinpointing the target, vaporize to achieve haemostasis. Complete the excision by pulling the specimen up and away firmly yet gently while cutting at the base

of the tissue.

ABLATION:

It depends on experience and kill as well as the type of ablative procedure performed. With the laser set at a power of 10W and with an impact spot of 3—4mm, begin with a short impact in the centre of the lesion. Repeat this with a continuous burst and move to the peripheral margin of the lesion. Stop when the surface has been totally treated. With a gauze soaked with hydrogen peroxide, clean off the resulting char. Repeat the vaporize—cleanse cycle until the bleeding is stable and the wound created appears reasonably uniform.

POST OPERATIVE INSTRUCTIONS [13]

i) Expect a sunburn- like reaction with possible blistering within the first 24-48 hrs. Pain is usually minimal and can be relieved with either analgesics and / or cool soaks with a wash cloth.

ii) A crust or scab may occur and should last for 7-14 days. Don't pick off the scab.

iii) Keep the area clean and dry until the scab / crust falls off. Wash gently with soap and water and apply a thin layer of moisturizer or antibiotic ointment.

iv) Once the scab / crust has come off the area may look pink and even slightly depressed or indented. Both the pinkness and depression should improve over the next several weeks to months.

v) Avoid direct sunlight or sun exposure to the treated area for 3-6 months. Use at least an SPF of 15 or greater sunscreen, or wear a hat or other protective clothing. Be aware that unprotected sun exposure can result in an uneven repigmentation, producing brown

spots that can take months to fade away and in rare cases may be permanent.

vi) Be patient === It may take up to three months to adequately judge the true response of condition subjected to treatment.

MATERIALS

A prospective analytical study was conducted in the department of dermatology, government stanley medical college and hospital, chennai, tamilnadu for a period of twenty five months from august 2004 to september 2006.

Sixty cases were serially selected from the OPD who fulfill the inclusion criteria. This includes approximately 20% of failure expected either in the response to treatment and follow up. Selected cases were included after fulfilling the criteria, serially numbered, written consent obtained, proforma filled and filed. They were subjected to laser treatment, the mode, the power, the frequency and the time of laser application calculated depending on the type and depth of lesion, site of involvement and patient's skin type. All the patients were treated under local anaesthesia (2% Xylocaine). Immediate side-effects were noted if any and the patients were followed up 1st week, 2nd week, 1st month, 2nd month, 6th month and 12th month. During the post treatment period the patients were treated with topical antibiotics (1% Silver Sulphadiazine cream) and topical sunscreen like Zinc oxide cream. Procedures were repeated at variable intervals depending upon the response and the results were analysed accordingly.

INCLUSION CRITERIA:

1.Uncomplicated benign skin and vascular conditions [Epidermal nevus, Intradermal naevus, Naevus sebaceous of jadassohn, Lentigines, Lymphangioma circumscriptum ,Angiokeratoma, Benign appendageal tumors, Angiofibroma, Xanthelasma, etc].

2. Tattoo

3. Hypertrophic scar

4. Patients who gave written consent for clinical photos and treatment

EXCLUSION CRITERIA:

1. Patients who were not willing to give written consent.

2. Secondary infections of the lesion to be treated.

CONDITIONS INCLUDED IN OUR STUDY:

ANGIOFIBROMA: [14, 15, 16, 17].

Facial angiofibroma are one of the major cutaneous manifestations of tuberous sclerosis complex occurring in about 90% of these patients resulting in significant cosmetic disfigurement leading to emotional distress. The lesions can be subjected to CO2 laser with cosmetically acceptable results. We tried CO2 laser in five patients.

INTRADERMAL NEVUS:[18]

It is an Acquired common melanocytic nevi characterized clinically by raised , dome shaped non-pigmented, sometimes pigmented nodules, mosty commonly seen on the face with often some overlying telangiectatic vessels and outgrowth of one or two coarse terminal hair over the surface.The lesions can be treated with CO2 laser. We tried CO2 laser in three patients.

NEVUS SEBACEOUS OF JADASSOHN:[19, 20].

Sebaceous nevi also known as organoid nevi are epidermal hamartomas predominantly of sebaceous glands characterized clinically by sharply circumscribed yellow-orange, verrucous plaques varying from a few mm to several cm occuring most commonly over head and neck area. It is difficult to treat and often the therapeutic outcome is unsatisfactory or cosmetically unacceptable.CO2 laser is very versatile laser which has been successfully used to treat lesions which were considered untreatable. We tried CO2 laser in two patients.

VERRUCOUS EPIDERMAL NEVUS: [19, 21, 22, 23, 24, 25, 26].

They are congenital non-inflammatory cutaneous hamartomas composed of keratinocytes characterized clinically by slightly pigmented velvety or warty streaks or plaques present since birth. With age, they darken and the surface becomes more warty. It is difficult to treat and often the therapeutic outcome is unsatisfactory. Co2 laser has been used successfully in treating epidermal Nevus.

We tried CO2 laser in 14 patients.

TATTOO REMOVAL:[27, 28].

Tattooing is the introduction of insoluble pigments into the skin to produce permanent pigment inscriptions and figures. Pigment is applied to the skin and then needles pierce the skin to force the material into the cutis. The pigment inserted may be carmine, indigo, India ink, chrome green, zinc oxide, cinnabar, cobalt blue, cadmium sulfide etc. Treatment for the removal of tattoo marks is usually unsatisfactory. Various modalities of treatment has been tried. Regarding lasers, Q-Switched Nd-YAG. Q-Switched Alexandrite, Q-Switched Ruby, Pulsed Dye laser and CO2 laser are all useful. We tried CO2 laser in two patients.

NAEVUS OF OTA:[29]

It was first described by Ota in 1939. It is also known as nevus fuscocaeruleus ophthalmomaxillaris. It is a dermal melanocytic hamartoma characterized by unilateral bluish brown macular discolorisation involving periorbital region, temple, forehead, malar area, and nose. There is frequently also a patchy blue discolorisation of the sclera

of the ipsilateral eye and occasionally also of the conjunctiva, cornea, and retina. The laser of choice in this condition is Q-Switched Ruby Laser(QSRL). So far combination of Co2 laser and Q-Swithched Ruby laser was tried in this condition. We tried CO2 laser in one patient.

LENTIGINES: [30, 31].

It is an uncommon syndrome probably determined by an autosomal dominant gene. It usually starts in the first year of life with the development of multiple brown or black macules distributed in a horizontal band across the centre of the face. The mucous membranes are not involved. They usually increased in the first decade of life. It may be associated with neurological features. It can be treated with CO2 laser, Argon laser,Q-Switched Nd-YAG and Ruby laser and cryotherapy etc. We tried CO2 laser in three patients.

LYMPHANGIOMA CIRCUMSCRIPTUM: [32, 33, 34, 35].

It is a malformation of lymphatic channels due to localized sequestration of embryonic mesenchymal masses clinically characterized by groups of deep-seated vesiclelike papules which is usually yellowish, but may be pink, red, or dark. They usually present at birth or shortly afterwards. They become more profuse during childhood and may persist indefinitely. So far CO2 laser has been used Successfully. We tried CO2 laser in two patients.

ANGIOKERATOMA OF FORDYCE:[32]

Known also an angioma of the Scrotum and Vulva. It is characterized clinically by multiple vascular papules 2 – 4 mm in diameter involving the scrotum or vulva affecting middle aged or elderly persons. So far CO2 laser has been used Successfully. We tried

CO2 laser in one patient.

MULTIPLE TRICHOEPITHELIOMA: [36, 37, 38].

It is a benign tumor with differentiation toward hair structures. It is also known as epithelioma adenoides cysticum and multiple benign cystic epithelioma. The inheritance is autosomal dominant and the lesions first appear in childhood and gradually increase in number. It is characterized clinically by numerous rounded, skin colored, firm, papules and nodules 2-8 mm in diameter mainly involving the nasolabial folds and also on the nose, forehead, and upper lip. Various therapeutic modalities like surgical excision, dermabrasion, electrocautery, CO2 laser etc were being tried. We tried CO2 laser in one patient.

SYRINGOMA: [18, 39, 40, 41].

It represents an adenoma of intraepidermal eccrine sweat duct affecting females predominantly at puberty. It is characterized clinically by multiple, small, skin-colored or slightly yellow, soft papules usually only 1 or 2 mm in diameter with common sites being the eyelids and upper cheeks. It can be treated with electrodessication and cryotherapy with liquid nitrogen. It can also be successfully treated with high energy pulsed CO2 laser. We tried CO2 laser in six patients.

COLLOID MILIUM:[42]

It is a degenerative change secondary to chronic sun exposure charactertised clinically by the development of skin colored or slightly yellow 1 – 3mm papules appear in the sun exposed areas of the hands, face, neck mand ears in the middle – aged adults. Improvement has been reported following dermabrasion, destruction of the lesions with diathermy or with cryotherapy has also been advocated, but the cosmetic results are seldom satisfactory. But Co2 laser would give excellent cosmetic results. We tried CO2

laser in one patient.

XANTHELASMA PALPEBRARUM: [43, 44, 45, 46, 47].

It is the most common type of xanthoma. It can be managed with surgical excision, trichloroacetic acid cauterization and fulguration. Surgical excision is the most widely used form of treatment. However, simple closure after excision of large lesions may restrict eyelid closure. The CO2 laser photovaporization method used for this purpose is simple and avoid the eyelid closure problems. We tried CO2 laser in one patient.

HYPERTROPHIC SCAR: [48, 49].

It represents an excessive connective tissue response to injury, which may be trivial. It can be managed with simple excision, silicone gel with adhesive tape, pressue alone or with occlusion, liquid nitrogen freezing and intralesional steroids. Hypertrophic scar can be resurfaced with Co2 laser. They are of limited efficacy and may even exacerbate the scarring process. We tried CO2 laser in one patient.

KELOID: [18,50, 51, 52, 53, 54].

It represents an excessive connective tissue response to injury, which may be trivial. It can be managed with simple excision, silicone gel with adhesive tape, pressue alone or with occlusion, liquid nitrogen freezing and intralesional steroids. Hypertrophic scar can be resurfaced with Co2 laser. They are of limited efficacy and may even exacerbate the scarring process. We tried CO2 laser in five patients.

ACNE KELOIDALIS NUCHAE:[55]

It is a chronic papular or pustular eruption localized to the nape of the neck and occipital area eventuating in keloid formation. It can be excised and vaporized successfully with CO2 laser. Although suggested in some reports, no clear advantage over other treatment

modalities has been established. We tried CO2 laser in one patient.

ACTINIC CHEILITIS: [56, 57, 58, 59, 60, 61].

Actinic cheilitis, a precancerous condition, more commonly affects lower lip and occurs predominantly in men and in fair-skinned persons with other signs of actinic damage. It can progress to invasive squamous cell carcinoma that may metastasize in up to 13% of cases. Several treatments have been advocated for actinic cheilitis, including cryosurgery, topical 5-fluorouracil, and vermilionectomy. Carbon dioxide laser vaporization has also been reported to be effective and well tolerated. We tried CO2 laser in one patient.

METHODS

ANGIOFIBROMA

SEX / AGE	*SITE*	*SETTINGS*	*INTERVALS*
3 Female patients; 15- 17yrs of age	Face	Power:4W Mode: CW Spot Size: 2mm No. of Sittings: 10	At an interval of 1-2 Months
2 Male Patients 20-30 yrs of age	Paranasal Area	Power:1W Mode: SP Spot Size: 0.2mm No. of sittings: One	At an interval of one month

INTRADERMAL NEVUS

SEX / AGE	*SITE*	*SETTINGS*	*INTERVAL*
1st Patient 26 / Female	Right Cheek	Power:4W Mode: CW Spot size:2mm No. of settings: 2	At an Interval of 1 Month
2nd Patient	Pre auricular area	Power:4W Mode: CW Spot size:2mm No. of settings:1	Single Sitting
3rd Patient	Tip of the Nose	Power:4W Mode: CW Spot size:2mm No of settings:1	Single Sitting

NEVUS SEBACEOUS OF JADASSOHN

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
1st Patient 25 Yrs / Male	Lt. Cheek	Power:4W Mode: CW Spot Size: 2mm No. of Sittings:3	II Sitting: One Month later III Sitting: 2 Weeks After 2nd
2nd Patient 19Yrs / Fch	Vertex	Power:1W Mode: SP Spot Size: 0.2mm No. Of Sittings:1	Single Sitting

VERRUCOUS EPIDERMAL NEVUS

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
7 patients 5-20yrs of age [4 females, 3 males]	Face, Nape of the Neck, Abdomen	Power: 4-5W Mode: CW Spot Size:2mm No. of Sittings:2-4	At an Interval of about 14 Days to One Month
7 Patients 5-20yrs of age [6 males, 1 female]	Face, Chest, Abdomen	Power: 1-2W Mode: SP Spot Size:0.2mm Sittings:2-4	At an Interval of about 14 Days to One Month

TATTOO REMOVAL

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
23yr/ Male	Rt. Side of Chest	Power:4 Watts Mode: CW Spot Size:2mm Sitting: One	Single Sitting

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
26 Yrs / Male	Lt. Side of Chest	Power:8 Watts Mode: CW Spot Size:2mm Sittings:3	At an Interval of One Month

NAEVUS OF OTA

AGE /	*SITE*	*SETTINGS*	*INTERVALS*

SEX			
28 Yrs / Male	Lt. Malar Area	Power: 1 Mode: SP Spot Size:0.2mm Sitting: Single	Single Sitting

LENTIGINES

.AGE / SEX	***SITE***	***SETTINGS***	***INTERVALS***
21 Yrs / Female	FACE	Power:1-2W Mode: CW Spot Size:1mm Sittings:20	At an Interval of about 3 – 4 Weeks
28 Yr / Male	Rt.Temple	Power:2W Mode: CW Spot Size: 1mm Sittings:4	At an Interval of about 3 – 4 Weeks
	FACE	Power: 1W Mode: CW Spot Size:1mm Sittings:4	At an Interval of about 3 – 4Weeks
25 Yrs / Male	FACE	Power:0.5W Mode: SP Spot Size:0.2mm Sittings: One	

LYMPHANGIOMA CIRCUMSCRIPTUM

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
23 yrs / FM	Rt. Side of Abdomen	Power:8W Mode: SP Spot Size:0.2mm Sittings:3	At an interval of about 3—6 Months
14 yrs / FM	Lt. Side of chest	Power: 4W Mode: CW Size: 2mm Sittings: Two	At an interval of about 2 weeks.

ANGIOKERATOMA OF FORDYCE

.AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
46 Yrs / Male	Root of the Penis Scrotum	For Both Sites Power:1W Mode: SP Spot Size:0.2mm Sittings: Single	Single Sitting

MULTIPLE TRICHOEPITHELIOMA

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
30 Yrs / Male	Nose	Power:2watts Mode: SP Spot Size:0.2mm Sittings:4	At an Interval of About 1—2Weeks at Various Sites Treated Site at an interval of 2 Weeks

SYRINGOMA

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
6 female patients, 20 - 30 years	Upper eyelid	Power: 1 watt Mode: SP Spot size: 0.2mm Sittings: Single	

COLLOID MILIUM

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
42 Yrs / FM	FACE	Power: 2W Mode: CW Spot Size: 2mm Sittings: Two	6 Months

XANTHELASMA PALPEBRARUM

Age / Sex	*Site*	*Settings*	*INTERVALS*
30 / FM	Upper Eyelid	Power: 0.5 W Mode: SP Spot size: 0.2mm Sittings: Two	Three weeks

HYPERTROPHIC SCAR

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
26Yrs / Female	Forehead	Power:1 Mode: SP Spot Size:0.2mm Sittings:4	At an interval of about of 3 — 4 weeks

KELOID

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
30 – 50 yrs / Males 5 Patients	Chest	Power: 8 –10 W Mode: SP Spot Size: 0.2mm Sittings: 4	One Month

ACNE KELOIDALIS NUCHAE

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
18 Yrs / Male	Nape of the neck	Power:6W Mode: CW Spot size:1mm Sittings: Two	Two weeks

ACTINIC CHEILITIS

AGE / SEX	*SITE*	*SETTINGS*	*INTERVALS*
50 / Male	Lower lip	Power: 4 W Mode: CW Spot size: 2mm Sittings: Single	

RESULTS

ANGIOFIBROMA

Age / Sex	***Site***	***Settings***	***1ST WEEK***	***1ST MONTH***	***1ST YEAR***
3 female patients; 15- 17yrs of age	Face	Power:4W Mode: Continuous wave (CW) Spot Size: 2mm No. of Sittings: 10	Ulcer in all the patients	Mild Postinflammatory Hyperpigmentation & Atrophy	Mild Postinflammatory Hyperpigmentation & Atrophy. Psoriasis in one Patient Relapse in one patient
2 Male Patients 20-30 yrs of age	Paranasal Area	Power:1W Mode: Superpulse (SP) Spot Size: 0.2mm No. of sittings:2	Ulcer	No Atrophy & Pigmentation	_____

INTRADERMAL NEVUS

Age / Sex	***Site***	***Settings***	***1st week***	***1stmonth***	***At the end of one year***
1st Patient	Right Cheek	Power:4W Mode: CW Spot size:2mm No. of settings: 1	Ulcer	Hyperpig mented patcth. No atrophy	No pigmentation & atrophy No relapse after one year

2nd Patient	Preauricular area	Power:4W Mode: CW Spot size:2mm No. of settings:1	Ulcer	Hyperpigmented patch. Mild atrophy	No pigmentation& Atrophy. No Relapse after one year
3rd Patient	Tip of the Nose	Power:4W Mode: CW Spot size:2mm No of settings:1	Ulcer	Slight Hyperpigmentation & No Atrophy	No Pigmentation and Atrophy No Relapse after 6 months

NEVUS SEBACEOUS OF JADASSOHN

Age / Sex	***Site***	***Settings***	***1st Week***	***1Month***	***1Year***
1st Patient	Lt. Cheek	Power:4W Mode: CW Spot Size: 2mm No. of Sittings:3	Ulceration, Erythema	Mild Hypopigmentation,Thikness of the plaque -- ↓ed	60% Dissappearance of lesion No Relapse
2nd Patient	Vertex	Power:1W Mode: SP Spot Size: 0.2mm No. Of Sittings:1	Ulcer	----------	Mild Scarring + No Relapse

VERRUCOUS EPIDERMAL NEVUS

Age / Sex	*Site*	*Settings*	*1st Week*	*1st Month*	*6th Month*
7 patients 5-20yrs of age [4 females, 3 males]	Face, Nape of the Neck, Abdomen	Power: 4-5W Mode: CW Spot Size:2mm No. of Sittings:2-4	Ulcer	Hypopigmentation No Atrophy	Hypopigmentation No atrophy Relapse in one patient Keloid in one Patient
7 Patients 5-20yrs of age [6 males, 1 female]	Face, Chest, Abdomen	Power: 1-2W Mode: SP Spot Size:0.2mm Sittings:2-4	Ulcer	Hypopigmentation Mild Atrophy	Hypopigmentation Milia Mild Atrophy Three Relapsed at the periphery of the lesions

TATTOO REMOVAL

Age / Sex	*Site*	*Settings*	*1 week Later*	*3 Month Later*
23yr/ Male	Rt. Side of Chest	Power:4 Watts Mode: CW Spot Size:2mm Sitting: One	Ulcer with Crusting	Significant Reduction in Pigmentation No atrophy

Age / Sex	*Site*	*Settings*	*1st Week*	*1 Month Later*	*4 months Later*

26 Yrs / Male	Lt. Side of Chest	Power:8 Watts Mode: CW Spot Size:2mm Sittings:3	Ulcer, Mild Hypopigmentation	Mild Decrease in Pigmentation No Atrophy	Moderate Decrease in Pigmentation And Keloid

NEVUS OF OTA

Age / Sex	***Site***	***Settings***	***1 Month Later***
28 Yrs / Male	Lt. Malar Area	Power: 1 Mode: SP Spot Size:0.2mm Sitting: Single	Slight Dcrease in Pigmentation

LENTIGINES

Age / Sex	***Site***	***Settings***	***8th Month***	***1st Yr***	***16th Month***
21 Yrs / Female	FACE	Power:1-2W Mode: CW Spot Size:1mm Sittings:20	Mild reduction in pigmentation	Moderate Reduction in Pigmentation	Significant Reduction in Pigmentation

Age / Sex	***Site***	***Settings***	***1st Week***	***End of 2nd month***
25 Yrs / Male	FACE	Power:0.5W Mode: SP	Ulceration & Crusting	Almost complete disappearance of

		Spot Size:0.2mm Sittings: One		lesions

Age / Sex	***Site***	***Settings***	***40th Day***	***55th Day***	***3rd Month***
28 Yr / Male	Rt.Temple FACE	Power:2W Mode: CW Spot Size: 2mm Sittings:4 Power: 1W Mode: CW Spot Size:1mm Sittings:4	Mild Reduction in size & Thickness Mild Erythema Mild Hypopigment ation No atrophy	50% reduction in size & Total Flattening Mild Erythema & Hypopigm entation No Atrophy	75% reduction in Size 50 – 70% reduction in pigmentation Mild Hypopigmentat ion and erythema No atrophy

LYMPHANGIOMA CIRCUMSCRIPTUM

Age / Sex	***Site***	***Settings***	***15days Later***	***45 days Later***	***1st Yr***	***18 Months Later***

23 yrs / FM	Rt. Side of Abdomen	Power:8W Mode: SP Spot Size:0.2mm Sittings:3	Ulcer	Decrease in thickness	No Scarring or Pigmentary Changes Relapse occured	Relapse Occured.

Age / Sex	Site	Settings	15 days Later	45 Days Later
14 yrs / FM	Lt. Side of Chest	Power: 4W Mode: CW Size: 2mm Sittings: Two	Mild erythema , hypopigmentation, and hyperpigmentation	90 % of lesions resolved. Mild hyperpigmentation

ANGIOKERATOMA OF FORDYCE

Age / Sex	***Site***	***Settings***	***1st Week***	***2nd Week***

46 Yrs / Male	Root of the Penis Scrotum	For Both Sites Power:1W Mode: SP Spot Size:0.2mm Sittings: Single	Ulcer Erythema	Penis: No Erythema / No Hypopigmentation Scrotum: Mild Hypopigmentation & Atrophy

MULTIPLE TRICHOEPITHELIOMA

Age / Sex	***Site***	***Settings***	***2nd week***	***3rd Week***	***1st Month***
30 Yrs / Male	Nose	Power:2watts Mode: SP Spot Size:0.2mm Sittings:4	Ulceration Crusting Erythema	Erythema Mild Redution in the size of Lesions	Erythema Moderate Redution in the Size of the Lesions

SYRINGOMA

Age / Sex	***Site***	***Settings***	***2nd week***	***3rd month***	***4th month***

6 female patients, 20 - 30 years	Upper eyelid	Power: 1 watt Mode: SP Spot size: 0.2mm Sittings: Single	Mild hypopigmentation and erythema. Slight atrophy	Mild hypopigmentation	No pigmentary changes

COLLOID MILIUM

Age / Sex	***Site***	***Settings***	***1st Week***	***6 Months later***	***One Yr Later***
42 Yrs / FM	FACE	Power: 2W Mode: CW Spot Size: 2mm Sittings: Two	Erythema Erosions	25% Reduction in the number of lesions	50% Reduction in the number of lesions Relapse present No scarring or Pigmentary changes

XANTHELASMA PALPEBRARUM

Age / Sex	***Site***	***Settings***	***3rd Week***	***2 Months later***
30 / FM	Upper Eyelid	Power: 0.5 W	Complete flattening	Almost complete disappearance of

		Mode: SP Spot size: 0.2mm Sittings: Two	of lesions	lesions Mild hypopigmentation

HYPERTROPHIC SCAR

Age / Sex	***S ite***	***Settings***	***1st Week***	***45th Day***	***2nd Month***
26Yrs / Femal e	Forehead	Power:1 Mode: SP Spot Size:0.2mm Sittings:4	Erythema Hypopigmentation	No Erythema Mild Reduction in Thickness of the Plaque	Moderate Reduction in Thickness Erythema Mild Hypopigmentation

KELOID

Age / Sex	***Site***	***Settings***	***1st Month***	***2nd Month***	***3rd Month***
30 – 50 yrs / Males 5 Patients	Chest	Power: 8 –10 W Mode: SP Spot Size: 0.2mm	Mild reduction in size	No change in size	No change in size

		Sittings: 4			

ACNE KELOIDALIS NUCHAE

Age / Sex	***Site***	***Settings***	***1st Week***	***2nd Week***	***One Month***
18 Yrs / Male	Nape of the neck	Power:6W Mode: CW Spot size:1mm Sittings: Two	Erosions Erythema	Erythema	No reduction in size

ACTINIC CHEILITIS

Age / Sex	***Site***	***Settings***	***One month later***

50 / Male	Lower lip	Power: 4 W Mode: CW Spot size: 2mm Sittings: Single	Almost complete disappearance of the lesion

DISCUSSION

ANGIOFIBROMA:

According to Bellack et al[16] CO2 laser is the treatment of choice for patients with extensive facial angiofibromas. In a study done by Kaushal K.Verma et al[16], four patients were treated with a power of 12-16 watts continuous defocused mode. At the end, all the patients had 50-80% improvement in their lesions. In another study by Papadavid et al[17], reported 77% improvement in lesions with continuous defocused mode at a power of 5-20 watts. In our study three female patients between 15 – 17 years of age and two male patients between 20 – 30 years of age with extensive angiofibromas were chosen. For both groups, the lesions are divided into different groups and each group of lesions were vaporized in single sitting. For the first group, the power used was 4 watts, continuous mode at a spot size of 2mm. Similarly, for the second group, the power used was one watts, superpulse at a spot size of 0.2mm. In the first group, patients developed mild postinflammatory hyperpigmentation and atrophy (Fig.1, 2, 3, 4). One patient in this group developed psoriasis vulgaris during the course of therapy as a koebner phenomenon (Fig.5). About 75% disappearance of lesions occurred in this group. In the second group, no pigmentary changes or atrophy were observed (Fig.6, 7, 8, 9, 10, 11). Perhaps better results would have been obtained with more treatment exposure and better patient compliance.

INTRADERMAL NAEVUS:

In a study conducted by Lawrence Khoo[18], 66 patients were treated with a power of 5-6 watts, superpulse mode. 86% achieved complete clearance, 14% had partial relapse and 6% relapsed totally. In our study three patients were treated for intradermal naevi with a power of four watts, continuous mode at a spot size of 2mm. All the patients

were followed up for a period of six months to one year. They developed hyperpigmentation by the end of one month and subsequently attained normal skin color(Fig.12,13,14,15,16). There was no relapse in all three patients (Fig.14,16). Patients were very well satisfied with the results and they attained 100% improvement.

NAEVUS SEBACEOUS OF JADASSOHN:

In a study done by Kaushal K.Verma et al[19], 4 patients were treated with 10-20 watts delivered in continuous defocused mode. Three patients showed 90% improvement and one patient showed 60% improvement. In our study, both patients were treated with 4 watts continuous wave defocused mode at a spot size of 2mm. Both of them developed ulceration and erythema which healed by the end of second week. In the first patient, there was 60% disappearance of lesion by the end of one year (Fig.17,18). The second patient showed complete disappearance of lesion with single sitting with a patch of hair loss with mild atrophy by the end of one year (Fig.19,20). Both the patients showed no relapse. But recurrences on a long term follow-up and in a larger group of patients needs to be evaluated.

VERRUCOUS EPIDERMAL NEVI:

In a study done by Kaushal K.Verma et al[19], 4 patients were treated with 10-20% watts in a continuous defocused mode. Three patients showed 80-90% improvement while one had poor (30%) response. In our study fourteen patients were taken and divided into two groups of seven each. First group treated with 4-5 watts continuous wave mode at a spot size of about 2mm. Another group treated with 1-2 watts super pulse mode at a spot size of 0.2mm. In the first group, 6 patients developed

hypopigmentation without atrophy (Fig.21,22,23,24,25,26,27). Only one patient showed relapse by the end of 3rd month(Fig.28). In the second group, all the patients developed hypopigmentation with mild atrphy (Fig.29, 30).One patient developed keloid (Fig.31) in the first group and another one developed milia like papules(Fig.32)in the second group. Three patients relapsed at the periphery of the lesions. We had a follow up of six months only except one patient. Therefore, recurrences on a longterm follow-up and in a larger group of patients needs to be evaluated.

If the treatment is superficial, with only the epidermis removed, the nevus regrows. If the treatment goes too deeply into the reticular dermis, a hypertrophic scar can develop. Therefore, vaporization or coagulation should be carried out into the papillary dermis. This procedure seems to reduce the chance of recurrence while minimizing the risk of scarring. The expected outcome after healing from this treatment is hypopigmentation.

TATTOO REMOVAL:

In a study conducted by Howard Levine and Philip Bailin[27], 16 patients were treated with approximately 15-25 watts with a spot size of 2mm. In all but two cases, removal of the pigment was complete after a single treatment. No true keloids developed and no hypertrophic scar formation persisted. In another study by Lanigan, Sheehan-Dare and Cotterill[28], 51 patients were treated with 10-20watts with defocused beam of 3mm diameter. An excellent or good response was seen in 2/3 rd of patients reviewed with an 8.5% incidence of hypertrophic scarring. In our study, two patients were taken and one of them is treated with 4watts continuous mode at a spot size of 2mm

and another one treated with 8watts continuous mode at a spot size of 2mm.In the first patient, there was 80% clearance of the lesion with two sittings without any atrophy and pigmentary changes (Fig.33, 34). The second patient showed 50% decrease in pigmentation after three sittings with keloid formation (Fig.36) after the third sitting but no atrophy (Fig.35, 36).

NEVUS OF OTA:

It is a dermal melanocytic hamartoma with the laser of choice being the Q-Switched Ruby laser. In one study, combination of CO2 laser and QSwitched Ruby laser was used[29]. But we have tried CO2 laser in one patient with a power of 1watt superpulse mode at a spot size of 0.2mm. There was 25% reduction in pigmentation with mild erythema with single sitting (Fig.37, 38). No hypopigmentation or atrophy were noted

LENTIGINES:

In a study done by Dover JS et.al[30]. 5 patients were treated with fluences of 3.0, 3.7 or 4.4 J/ cm2. six weeks latwer, 9.9% of lesions cleared completely, 66.9% of lesions lightened substantially and 23.1% of lesions remained unchanged. In our study, 21 year old female patient with centrofacial lentiginosis treated with 1 - 2 watts continuous mode at a spot size of 1mm. There was 90% decrease in pigmentation after twenty sittings without scarring (Fig.39, 40). Another two patients with facial lentiginosis were treated with 1-2 watts continuous wave mode at a spot size of 1mm. The first patient with lesions over the face showed almost complete disappearance of lesions on both sides of face with single sitting after two months (Fig.41, 42, 43). In the second patient, the temple lesion

showed 75% reduction in size as well as in pigmentation without atrophy after four sittings (Fig.44, 45, 46). The face lesions showed 50-70% reduction in pigmentation with mild hypopigmentation and erythema without atrophy after four sittings (Fig.47, 48, 49, 50).

LYMPHANGIOMA CIRCUMSCRIPTUM

In a study done by Joyce lim[32], 7 patients with lymphangioma circumscriptum were treated with CO2 laser. But the results were disappointing with either recurrences or scarring. In our study, two female patients were chosen and one of them was treated with 8 watts superpulse mode at a spot size of 0.2mm and another one treated with 4 watts continuous mode at a spot size of 2mm. In the first patient, there was no improvement at all with relapse occurred 18 months later (Fig.51, 52). The second patient showed 90% improvement in lesions with mild hyperpigmentation after two sittings (Fig.53, 54) and should be followed up over a long period to watch out for any recurrences at the same site.

ANGIOKERATOMA OF FORDYCE

In a study done by Joyce Lim[32], 9 patients with angiokeratoma of the vulva or scrotum were treated with the CO2 laser and the lesions cleared. However it did not prevent recurrences. In our study, 46 year old male patient was treated with 1watt superpulse mode at a spot size of 0.2mm. All the lesions are cleared without erythema and pigmentary changes over the penis and with mild hypopigmentation and atrophy over the scrotum (Fig.55, 56). But the patients should be followed up over a long period to watch out for any recurrence at the same site.

MULTIPLE TRICHOEPITHELIOMA:

In a study done by A.L.Gerretsen and J.Toonstra[37], a 35 year old woman was treated with 4-5 watts continuous defocused mode. The cosmetic result was very satisfactory with only minimal scarring after five separate sessions. In our study, 30year old male patient was treated with 2watts superpulse mode at a spot size of 0.2mm. Patient showed erythema with moderate reduction in the number and size of the lesions after four sittings (Fig.57, 58). Perhaps better results would have been obtained with frequent treatment exposures and better patient compliance.

. **SYRINGOMA**

In a study done by Lawrence Khoo[18], 90 patients were treated with 5-6 watts superpulse mode. 76% of the patients were followed up for a mean of 6.9 months. 56% achieved complete clearance, 40% had partial relapse and 4% relapsed totally. 8.6% developed mild depressed scarring, 8.6% had transient post treatment hyperpigmentation and 4% had hypopigmentation. In our study, 6 patients were treated with 1watt superpulse mode at a spot size of 0.2mm. Three patients achieved complete clearance and three patients showed relapse after single sitting over a follow up period of 3-4 months (Fig.59, 60).

All patients developed mild hypopigmentation with slight atrophy. But the patients should be followed up over a long period to watch out for any recurrences

COLLOID MILIUM

In a study done by Kullavani Jaya P[42], CO2 laser was used in the treatment of topical hydroquinone induced colloid milium. The CO2 laser treatments were performed

with good results. In our study, 42 year old female patient with lesions over the face was treated with 2 watts continuous mode at a spot size of 2mm at an interval of 6 months. There was 25% reduction in the number of lesions with single sitting. Subsequently there was 50% reduction in the number of lesions after two sittings without atrophy or pigmentary changes (Fig.61, 62). The patient showed relapse after eight months (Fig.62).

XANTHELASMA PALPEBRARUM:

In a study done by Yehuda Ullman, Yaron Harshai and Isaac J.Peled[43], 22 patients were selected and treated with 3-5 watts (depending on the thickness of the plaque) continuous mode at a spot size of 1mm. Out of 22 patients, only 4 patients required two sessions and the other patients were treated in one session. 59% 0f the patients showed excellent results and 41% of the patients showed good response. Recurrence rate was found to be 9%. Pigmentary changes were noted as follows: hypopigmentation(18%); hyperpigmentation (5%). No eyelid retraction. In our study, a 30 year old normolipemic female patient was treated with 0.5watt superpulse at a spot size of 0.1mm. There was complete flattening of lesions by third week after first sitting (Fig.63,64). There was almost complete disappearance of the lesion with mild hypopigmentation after two sittings (Fig.65). No atrophy was noted.

HYPERTROPHIC SCAR:

In a study done by Alster TS, Lewis AB and Rosenbach A[48], twenty patients with nonerythematous hypertrophic scar were treated with high-energy, pulsed co2 laser. Global assessment scores and erythema spectrometry measurements were significantly

improved after treatment.

In our study, one patient with scar on the forehead was treated with 1watt superpulse mode at a spot size of 0.2mm. There was 75% reduction in the thickness of the scar with mild erythema and hypopigmentation (Fig.66, 67). The pigmentary changes will resolve over a period of time.

KELOID

In a study done by Kantor GR et al[50], there were 17 recurrences in a group of 23 keloids excised by laser. In another study by Apfelberg DB et al[51], seven patients with keloids have been treated by excision with the CO2 laser. Eight of the the nine keloids have recurred to their original or close the original site. Only one patient has greatly improved after only 9 months follow up. The long term benefits of keloid excision with the CO2 laser is not demonstrated in this case study series. In another study by Lawrence Khoo[18], 9 patients were treated for keloids. The keloids would be debulked using either continuous or superpulse mode with an average power of 6-8 watts. This would then be followed by ablation of the remaining keloid. 89% of the patients were followed up for a mean of 7.6 months.22% achieved complete clearance, 75% had partial relapse. No complication was noted after treatment. In a review article by Mutalik sharad[52],, ample reports have demonstrated the use of CO2 laser for ablating the keloid lesions, but similar to the excision modality, the failure rate is 100% as the laser ablation actually burns the lesions.

In our study, five patients were treated with 8 - 10watts superpulse mode at a spot size of 0.2mm. There was recurrence even after five sittings in all patients (Fig.68, 69).

ACNE KELOIDALIS NUCHAE

In a study done by Kantor GR et al[55], CO2 laser was used in the treatment of refractory acne keloidalis nuchae with good results. In our study, a male patient was treated with 6 watts continuous mode at a spot size of 1mm. There was no improvement at all with relapse occurred after 2 sittings (Fig.70,71).

ACTINIC CHEILITIS

In a study done by George J.Hruza[56], actinic cheilitis was treated with 3-7 watts continuous mode and healing takes place upto 4 weeks with excellent response. In another study by Dufresne RJ Jr et al[57], 13 patients were treated with both conventional and superpulsed modes. The procedure was well tolerated. Focal, but not functionally restricting, scarring developed in three patients. The cosmetic result was otherwise excellent. No recurrences have been noted. In our study, 50 year old male patient was treated with 4 watts continuous mode at a spot size of 2mm. One month later, there was 90% clearance of the lesions with single sitting (Fig. 72, 73).

CONCLUSION

1. In our study, CO2 laser gave excellent results in conditions like Actinic cheilitis, Intradermal nevus, Verrucous epidermal nevus, Xanthelasma palpebrarum and Syringoma.

2. In our study, CO2 laser gave good results in conditions like Angiofibroma, Tattoo removal, Hypertrophic scar and Angiokeratoma of Fordyce.

3. In conditions like, Multiple Trichoepithelioma, Nevus of Ota and Colloid milium, there was only minimal improvement. Perhaps better results would have been obtained with more treatment exposures and better patient compliance.

4. In conditions like, Keloid, Acne keloidalis nuchae and Lymphangioma circumscriptum, there was high incidence of recurrences even after adequate treatment sessions.

5. The conditions included in our study should be followed up over a long period to watch out for any recurrences following CO2 laser treatment.

6. The side effects like hypopigmentation, hyperpigmentation and mild atrophy would resolve over a period of time.

7. Keloidal scars were developed in two cases following the treatment of verrucous epidermal nevus and tattoo removal which may be due to the inherent tendency of the patients.

8. CO2 laser offers a well tolerated treatment modality without compromising the cosmetic aspects.

9. The CO2 laser is a good method of treatment for various benign skin lesions, especially where precise tissue ablation and concomitant haemostasis are desired.

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STANLEY MEDICAL COLLEGE HOSPITAL

DEPT. OF DERMATOLOGY

PROFORMA

Name :

OP No :

Age :

Sex :

Address :

Clinical Description :

Distribution of the lesion :

Clinical Diagnosis :

Pre-treatment Photographs : **Yes** **No**

CO2 laser treatment :

Mode -Continuous, Superpulse, Repetitive, Single

On-time -

Off-time -

Power - Watts

Spot Size -

Post Laser Medication :

Review

7 Days -

15 Days -

30 Days -

60 Days -

Posttreatment Photographs - Yes No

Response : Fair, Good, Excellent

Complication :

Written Consent by the patient for the clinical photos and Treatment