

**EFFECTIVENESS OF CO₂ LASER AND
MICRODERMABRASION IN PATIENTS WITH ACNE
SCARS**

DISSERTATION

submitted in fulfillment of the university regulations for

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CERTIFICATE

Certified that this dissertation entitled “**EFFECTIVENESS OF CO₂ LASER AND MICRODERMABRASION IN PATIENTS WITH ACNE SCARS** ” is a bonafide work done by **Dr. Y.G. ANUPAMA**, Post Graduate Student in M.D. Dermatology, Venereology and Leprosy, Madras Medical College, Chennai – 600 003, during the academic year 2007 – 2010. This work has not been formed previously the basis for the award of any degree.

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INTRODUCTION

Acne is a common disorder affecting pilosebaceous units, clinically characterized by the presence of comedones, inflammatory papules, pustules and some nodules and cysts arising during adolescence. It is one of the most common causes of facial scarring.

Post-acne facial scarring is a psychologically devastating condition and the affected patient invariably suffers from low self-esteem and many other psychological ill-effects¹. Facial scarring has always been a challenge to treat and there are different treatment options for the management of these scars.

Facial atrophic scars can be safely and effectively resurfaced through the proper use of a high-energy, pulsed or scanned carbon dioxide (CO₂) lasers. These laser systems emit high energy densities within extremely short pulses that effect tissue vaporization with limited thermal conduction to non-targeted surrounding skin. Since each laser pass effects a predictable and reproducible amount of tissue vaporization and residual thermal damage, as much or as little tissue can be removed as required by the type of scar being treated. Immediate collagen shrinkage, later with subsequent collagen remodeling develops, which accounts for the clinical benefits following resurfacing.

Microdermabrasion is a superficial, office-based, minimally invasive technique of mechanical abrasion of the skin using a pressurized stream of particles such as aluminum oxide crystals. It may also be performed with a disposable or reusable diamond tip. There is superficial wounding of the skin, followed by epithelialization,

stimulation of epidermal cell turnover and it also cause stimulation and remodeling of dermal collagen. It is mainly indicated for the treatment of superficial acne scars and is ineffective for deeper scars.

This study attempts to find the therapeutic response to CO₂ laser treatment and microdermabrasion in patients with acne scars.

REVIEW OF LITERATURE

Acne vulgaris is a chronic inflammatory, self-limited disease of the pilosebaceous unit, seen primarily in 80% of adolescents clinically characterized by the formation of comedones, papules, pustules, nodules or pseudo cysts. While many people recover from acne without any permanent effects, some people are left with disfiguring acne scars.

A survey² of acne patients conducted in France reported 49% of them had scars, in which 14% of them were females and 11% males. In another study, 95% of acne scar occurred on face and there was no gender difference³. However, acne scars on the trunk were common in males. As per the work done by Apfelberg et. al.⁴, the mean age for acne scars was around 24.6 years.

Formal evaluation of the incidence of acne scarring in the context of acne severity and lesion type was first initiated by Layton et. al⁵. Of the atrophic acne scars, ice pick scars were most frequent on the face, while follicular macular atrophic scars were observed on the torso. Acne scarring scores were significantly higher in males at all sites for each initial Leeds acne score.

The occurrence and incidence of scarring is still not understood. However, there is a considerable variation in scarring between one person and another, indicating that some people are more prone to scarring than others.

Genetic factors may have an impact on the predisposition to scarring, and the type of scarring⁶.

Acne left and untreated for up to three years correlated significantly with progressively higher scar scores on the face and trunk. Beyond this time, no further increase in scar scores was observed.

Scarring frequently results from severe inflammatory nodulocystic acne that occurs deep in the skin. In some, scars may arise from more superficial inflamed lesions. While 85% of those with hypertrophic/keloidal scars had suffered from nodular inflammatory acne at some period in the course of their disease, 15% had reported only superficial inflammatory lesions.

Inflamed lesions are formed by the body's inflammatory response to sebum, bacteria and dead cells in the plugged sebaceous follicle. If the follicle ruptures near the skin's surface the lesion is usually minor and heals quickly. More severe lesions arise when there is a rupture deep in the follicle wall. The infected material spills out into the dermis, and destroys the healthy skin tissue. To repair the damage done to the dermis, skin forms new collagen fibers.

People also have different feelings about acne scars. Scars of more or less the same size that may be psychologically distressing to one person may be accepted by another.

Acne Scars Classification⁷

Classification is essential to assess the severity of cosmetic disfigurement and to choose the therapeutic intervention necessary. Acne scars are broadly classified as follows:

1. Scars caused by increased tissue formation

- a. Keloids
- b. Hypertrophic scars

Both are associated with excessive amounts of collagen which is piled up in fibrous masses, resulting in a characteristic firm, smooth usually irregularly shaped scars.

2. Scars caused by loss of tissues

Ice pick scars – These are narrow, < 2mm, deep, sharply margined with vertical epithelial tracts which are wider at the skin surface and taper down extending into the deep dermis or subcutaneous tissue.

Rolling Scars – They occur from dermal tethering of otherwise relatively normal looking skin. They are shallow and are usually wider than 4-5 mm. The abnormal fibrous anchoring of the dermis to subcutis leads to superficial shadowing and rolling or undulating appearance of the overlying skin surface.

Boxcar Scars – They are round or oval depression with sharply demarcated vertical edges. They do not taper like ice pick scars. They may be shallow (up to 0.5mm) or deep (> 0.5 mm) and most often 1.5 to 4mm in diameter.

Atrophic Macules – These are small when they occur on the face, but may be larger on the body. They are soft, with a slightly wrinkled base, and may be bluish in appearance. Over time these scars change from bluish to ivory white in white skin people and become less obvious.

Follicular Macular Atrophy – These are small, white, soft lesion often raised above the surface of the skin. Also called as perifollicular elastolysis, they normally occur on the chest and back.

European acne group has renamed the atrophic acne scars as V-shaped (ice-pick), U-shaped (box car) and W-shaped (rolling) ⁸.

Grading of acne scars

Objective evaluation of the scars is necessary for discussion, treatment and research. Different grading scales are used to grade acne scars for day-to-day implementation:

1. According to Goodman and Baron⁹ acne scars can be categorized as:

- *Grade 1* – macular erythematous, hypo or hyperpigmented scars.
- *Grade 2* – mild atrophy that is visible at distances of less than 50cm and can be covered by make-up or beard hair. Examples include mild rolling acne scars.
- *Grade 3* – moderate disease that is visible at 50cm or greater; not easily covered with make-up or the normal shadow of a shaved beard hair. Stretching the skin can flatten the scar. Examples include more significant rolling scars, shallow boxcar scars, and mild to moderate hypertrophic scars.
- *Grade 4* – severe disease as in grade 3 but scarring is not flattened by stretching the skin. Examples include severe boxcar, ice pick scars, and hypertrophic/keloid scarring.

The advantages of this system include simplicity, ease of application in practice and relevance to patients and physicians with regard to corrective procedures.

2. In the study by Layton *et al.*⁵ conducted at the Leeds General Infirmary, the severity of acne scarring was evaluated by lesion counts of atrophic and hypertrophic/keloidal scars. The number of atrophic scars such as ice-pick, macular atrophic or follicular macular atrophic, are translated into scores ranging from 1 to 6 representing 1-5, 6-10, 11-25, 26-50, 51-100 and more than 100 scars, respectively.

A total scar score was then obtained by adding the scores. Such total scores could be calculated separately for the face, chest and back to provide a comprehensive system for scar evaluation. A potential limitation of this system is the time required for calculation of the relevant scar scores.

3. The ECCA (Echelle d'Evaluation clinique des Cicatrices d'acné)¹⁰ for facial acne scarring is based on summation of individual types of scars and their numerical extent. Specific scar types and associated weightage factors are the following:

- Atrophic scars with diameter less than 2 mm: 15
- U-shaped atrophic scars with a diameter of 2-4 mm: 20
- M-shaped atrophic scars with diameter greater than 4 mm: 25
- Superficial elastolysis: 30

- Hypertrophic scars with a less than 2-year duration: 40
- Hypertrophic scars of greater than 2-year duration: 50

A semi-quantitative assessment of the number of each of these scar types is then determined with a four-point scale, in which 0 indicates no scars, 1 indicates less than five scars, 2 indicates between five and 20 scars and 3 indicates more than 20 scars. In this manner, the relative extent of scarring for each scar type is calculated. The summation scores for all six scar types comprise the global scar score, which could vary from 0 to 540.

The potential advantages of this system include independent accounting of specific scar types, thereby providing for separate atrophic and hypertrophic subscores in addition to total scores. Potential shortcomings include restriction to facial involvement, time insensitivity and undetermined clinical relevance of score ranges.

4. A quantitative global scarring grading system was also presented by the same authors Goodman and Baron¹¹ in which different types of scars are accorded increasing scores (macular or mildly atrophic: 1 point; moderately atrophic: 2 points; punched out or linear-troughed severe scars: 3 points; hyperplastic papular scars: 4 points). The multiplication factor for these lesion types is based on the numerical range whereby, for one to ten scars, the multiplier is 1; for 11-20 it is 2; and for more than 20 it is 3. For hypertrophic/keloidal scars, scores are allocated depending on the size of these lesions, whereby an area of less than 5 cm² involvement is given 6 points,

5-120 cm² 12 points, and larger than 20 cm² 18 points. The upper limit of this system has a score of 84. This system is time-intensive.

Prevention of Acne Scars: The only sure method of preventing or limiting the extent of scars is to treat acne early in its course and as long as it is necessary in order to decrease the inflammation.

Treatment

The morphology of each scar must be assessed, and treatment designed according to the types of scars, overall appearance and expectations of the patient¹². The patient must be adequately counseled that the goal of treatment is improvement rather than perfection, as deep acne scars cannot be entirely eliminated.

Medical management

There are numerous medical options available for the treatment of acne scars. Hypertrophic scars, keloids, and pigmentary changes are the usual focus of medical management whereas the other types of scars require interventional treatment. Cortocosteroids (triamcinolone, hydrocortisone, methyl prednisone, dexamethasone) are used topically with or without occlusion or intralesionally for keloids and hypertrophic scars with variable results. Common side effects include necrosis, allergy, atrophy and telangiectasia. Silicone dressings are also used for hypertrophic scars but without

convincing efficacy¹³.

Surgical Management

It is an essential tool in the armamentarium against acne scarring.

Chemical peeling is a method of treating more superficial acne scarring. Generally, medium to deep chemical peels are required to achieve a significant result, but a series of more superficial chemical peels could help achieve some improvement in milder acne scarring without significant downtime¹⁴.

TCA CROSS is a simple yet effective method of improving acne scarring. It is most commonly used for small indented acne scars. It involves careful placement of high concentrations of trichloroacetic acid into the scar with a toothpick. This stimulates the production of new collagen and remodeling of existing collagen to fill in the acne scar. The advantage of this treatment is that it is localized to the problem only and not the unaffected skin¹⁵.

Microdermabrasion is a technique which helps mild acne scarring. It uses a gentle vacuum to bring the skin in contact with a diamond-coated head or aluminum oxide crystal that gently abrades the top layer of dead skin. This stimulates collagen production and helps treat scarring. 10 to 15 sessions of microdermabrasion may be useful in superficial U scars¹⁶.

Subcision is another technique that is suitable for treating depressed acne scars.

The size of the scar usually needs to be fairly large or deep. It involves putting a special needle under the depressed scar. Often acne scars are depressed because the skin is tethered to the underlying tissues. Subcision helps to release it from the underlying structures. It is often combined with skin needling, TCA CROSS or other laser treatments¹⁷.

Skin needling is an effective method of treating superficial acne scars by puncturing the skin with multiple fine 3mm (long) needles. This stimulates collagen production and helps to lift up any 'indented' scars. The advantage of this treatment is the fact that it can be used on all skin types including darker skin types.

Dermabrasion is a method used to resurface acne scars. This involves planing the top layers of the skin with prolonged healing time and significant risk¹⁸.

Laser resurfacing with a carbon dioxide laser is used for acne scarring. These lasers have been used for over a decade to resurface skin. They ablate (vaporize) the top layer of skin and this stimulates growth of new skin and collagen to help reduce the appearance of scarring.

More recently, fractional lasers have been used for the treatment of acne scarring¹⁹. Instead of treating the whole skin surface, small columns of laser energy are fired into the skin, and the skin in between these columns is spared. This leads to faster healing time, and less risks and complications from treatment.

CO₂ LASER

Laser is an acronym for “Light Amplification by Stimulated Emission of Radiation²⁰”. Stimulated emission was based on Einstein’s quantum theory of radiation. The first laser was produced by Theodore H. Maiman on 7th July 1960 using ruby as a lasing medium that was stimulated using high energy flashes of intense light. The pioneering work in the dermatological application of laser was done by Dr. Leon Goldman who is considered to be the father of laser medicine.

CO₂ laser was introduced in 1964 and is called the ‘work horse’ due to its wide use as a cutting ablative laser²¹. In the 1980’s and the early 1990’s continuous wave (CW) CO₂ lasers were used for photo-aged skin²². Several new CO₂ laser systems have been introduced with high peak power short pulse duration and rapidly scanning devices to treat a variety of dermatological conditions²³.

In a study done by Alster et. al.²⁴ for 50 patients showed scar improvement of 70-90% with a mean of 81.4%. In another study done by Bernstein et. al. 50-75% showed improvement. It was found that, 36% of patients had transient hyperpigmentation, although it resolved in 3 months. Fourteen per cent of patients developed milia, but there were no bacterial and fungal infections.

A significant understanding of lasers and light sources is required for their optimal use. Also a basic understanding of laser physics is mandatory to carry out an

efficient laser treatment.

Laser Characteristics²⁵

Laser radiation as a form of light is part of the electromagnetic spectrum. Laser light differs from standard light like sunlight or incandescent light on a number of aspects.

Laser is formed of *monochromatic photon* i.e. light from a given source is of a single wavelength. This property enables lasers to selectively target chromophores in the skin with a corresponding single wavelength.

Laser light is *coherent*, i.e. the waves of energy are in phase with each other both in space and in time.

Laser light is also *collimated* i.e. the laser beam component waves are highly parallel, producing a narrow beam that can be propagated for long distances with minimal divergence or convergence.

Parameters of Laser Light²⁶

The interaction of laser energy with the tissue depends on a number of factors including power, spot size, duration of exposure, wavelength and tissue properties. In order to achieve consistency in performance the following parameters have to be considered.

1. Energy that is contained in the light is expressed in joules.
2. Power is defined as the time rate at which energy is emitted by the laser and is measured in watts (joules/second).
3. Irradiance or power density is the concentration of the beam of light and is expressed as the power applied per unit area (watts/cm²). This determines the ability of a laser to coagulate, vaporize or incise tissue.
4. Fluence or energy density is the actual amount of energy applied to the unit area of target tissue and depends on the exposure time.

Fluence (joules/cm²) = Power x exposure time (seconds) / area (cm²).

Smaller the radius of the laser beam (spot size), higher is its Fluence.

5. The wavelength of light emitted by a laser gives it its characteristic color (green, red, yellow) within the visible range and is measured in nanometers (nm).
6. Pulse duration is the amount of time the laser energy is applied (ns, ms).
7. Pulse frequency is measured in hertz. (Hz = 1 pulse / second). It is the repetition rate of pulse.
8. Transverse electronic mode (TEM) is the distribution of energy across the laser beam diameter.
9. Modes of output (i.e. delivery): The light is delivered in two broad categories described according to whether the beam is delivered in a continuous wave (eg. Carbon dioxide – CO₂ laser) or in a pulse wave.
 - a. In the continuous wave (CW) mode, there is an uninterrupted (constant) beam of radiation of relatively low power. Energy is delivered at some mean level (power density, spot size) continuously for as long as the operator wants (e.g. argon laser, CO₂ laser). The advantages are that larger areas can be treated rapidly with lesser time consumption. The disadvantage is its reduced safety profile and thus more chance of side effects and complications.

b. In the pulse mode, the continuous beam can be interrupted (on and off) to form pulses when light is emitted in bursts of low energy but with peak powers. This is achieved by cutting the beam either with simple mechanical shutters, electronically operated switches, mode locking, Quality switching or through controlled pumping and discharge. These mechanisms produce a single pulse, multiple pulses or pulse trains with a width or duration ranging from milli to several hundred micro to nano seconds. Simple pulsed lasers produce the same peak power as continuous wave, whereas super-pulsed and ultra-pulsed lasers produce higher peak power with lesser pulse durations. In Q-switched mode the pulse is of very short duration with further increase in the peak power. The pulse systems allow improved energy delivery systems allow improved energy delivery systems with uniform dose of radiation across the treatment area as compared to CW lasers. There is a highly safety profile because these systems minimize the thermal injury by allowing for tissue “cooling phase” during the “off” portion of the cycle. However the disadvantages is that it is more time consuming than CW systems.

Selective Photothermolysis

It was introduced in 1983 by Anderson and Parrish²⁷. The theory of selective thermolysis refers to laser energy being absorbed by a target chromophore without significant damage to surrounding tissue.

Selective photothermolysis can be achieved by:

1. Producing a beam of light with a wavelength that is preferentially absorbed by that chromophore.
2. Keeping the Fluence high enough to thermally alter the target.
3. By shortening the pulse duration to less than the thermal relaxation time of the chromophore, thereby allowing it time to cool by conducting heat to surrounding tissues – thus preventing damage to them.

Components of CO₂ Laser System²⁶

Laser medium – A mixture of CO₂, nitrogen and helium (1:1.5:4)

Optical Cavity – Encloses the lasing medium and amplification process takes place here

Energy Source – Required for the amplification process. This may be direct electric current, radio frequency waves, optical flash or energy derived from chemical reaction

Delivery System - Brings the laser beam from the machine to the patient. It uses a series of articulating joints and mirror to produce far infrared light of longer wavelength.

Mechanism of action^{28, 29}

- CO₂ laser emits invisible far infrared light at 10,600 nanometer, either in a

continuous wave or pulse/super-pulsed/ultra-pulsed mode.

- The depth of penetration is 0.1 mm per pass and 90% of it is selectively absorbed by tissue water which is its target chromophore.
- Based on the principle of selective thermolysis, the target chromophore gets heated and thermally damaged by the observed laser energy.
- When the heating is rapid all the tissue water is vaporized as steam and the tissue structures explode due to rapid thermal expansion of water, sharp waves and cavitations effects (tissue ablation). These tissue debris together with steam form the “plume”.

The vaporization occurs in the most superficial layers of tissue (zone of vaporization). Below the vaporized layer is a zone of tissue heated between 70°C to 100°C resulting in tissue necrosis (zone of irreversible damage). Deeper to this, there is a zone of tissue that is heated between 35° C to 70° C (Zone of reversible damage) resulting in shrinkage of collagen. All these thermal effects are responsible for the basic tissue changes which are observed: ablation, tightening, remodeling, and reepithelialization. If multiple pulses rapidly impact the same tissue (pulse stacking) then significant cumulative thermal injury occurs resulting in deeper wound and scarring.

The factors affecting the tissue destruction by laser are:

- The power reaching the tissue.
- Spot size: This can be changed either by defocusing the beam keeping the hand piece away from the treated area, or, by focusing the beam keeping it nearer to the area. Spot size of 2-5mm is typically used for vaporization.
- Thermal relaxation time (time between heating of tissues by the laser beam and cooling of tissues).

Clinical Applications: The CO₂ laser is used to perform various types of surgeries through its two modes of action i.e. either the excisional / cutting mode or vaporizational / ablative mode.

- The excision mode employs a focused small spot size beam of high power to create sufficient intensity to cut soft tissues.
- A large beam of low power is used in vaporizing mode to precisely ablate the soft tissue superficially.

Both these actions are achieved either with continuous mode or pulse / super-pulse / ultra-pulse system of lasers.

Indications

- Facial scars³⁰ – acne, chicken pox, herpes zoster, traumatic.
- Hyperkeratotic lesions – Lichen simplex chronicus, papular lichen amyloidosis, porokeratosis, linear verrucous naevus.
- Appendageal lesions - neurofibroma cylindroma, syringoma, adenoma sebaceum³¹, multiple trichoepitheliomas, sebaceous hyperplasia, epidermal naevi.
- Vascular lesions – lymphangioma circumscriptum³², angiokeratoma, pyogenic granuloma.
- Premalignant and malignant lesions – actinic keratoses, actinic cheilitis, leukoplakia, Bowen's disease³³, extra mammary Paget's disease, erythroplasia of Queret, superficial basal cell carcinoma.
- Stable vitiligo - Therapeutic adjuvant (spot) and before grafting.
- Pigmentation – Melasma, melanosis, tattoos, lentigines, etc.
- Miscellaneous – photoaging³⁴, rejuvenation, xanthelasma³⁵, keloid.

Contraindications^{32,35}

- Isotretinoin use within the previous six months
- Active cutaneous bacterial or viral infection
- Ectropion
- Keloidal tendency
- Collagen vascular disease
- Ongoing ultraviolet exposure
- Prior radiation therapy to treatment area

Patient Information

- Realistic expectation of the outcome (50%-80%) improvement and not complete elimination.
- Post operative sequelae, side effects and complications
- Post operative sun protection for 3-6 months.

Pre Operative Work up

- Complete blood count
- Blood sugar
- Screening for hepatitis B, VDRL, HIV

- Informed consent and photographs
- Prophylactic acyclovir / famciclovir in patients with history of herpes simplex

Procedure^{21,22}

1. The skin is cleansed and degreased with acetone.
2. Topical anesthesia (EMLA) is applied.
3. Protective safety gears are worn by patient (eye glasses) and operator (eye glasses, masks, gloves).
4. The face is turned to one side and the handpiece is moved placing a series of multiple laser impacts along the edge of the scar and at the center. If required, one more pass is made along the edge of scar.
5. All the scars are treated one by one in a similar fashion.

Post Operative Management

- Sunscreens and emollients are prescribed for the next one to two weeks.
- Direct sunlight is avoided for 3-6 months.

Complications³⁶

Usual events – pain, oedema, exudation, discomfort, crusting, erythema.

Side effects – persistent erythema, hyperpigmentation, permanent hypopigmentation, exacerbation of acne, secondary infection, allergic contact dermatitis, scarring, ectropion, keloid formation.

Advantages

- Excellent cosmetic improvement (50%-80%).
- All the scars can be treated at one time.

Disadvantages

- Expensive
- Sun protection and prolonged post operative cream application
- Permanent hypopigmentation
- Deep ice pick scars cannot be corrected by laser alone.

Subcision¹⁷ is a minimally invasive, safe, permanently effective, and economical office procedure. The subcision releases fibrous anchoring of dermis using 24G hypodermic needle, under aseptic precautions and the resultant hematoma, newer matrix and collagen tissue laid down together are responsible for the immediate clinical improvement in rolling post-acne scars. Later CO₂ laser procedure is followed for better improvement.

MICRODERMABRASION

Microdermabrasion, also known as ‘body polishing’ is a simple and safe cosmetic resurfacing procedure consisting of mechanical abrasion of the skin with pressurized stream of ammonium oxide crystals or other abrasive substances so as to achieve superficial skin wounding³⁷. It has gained popularity in the last five years.

History Ancient Egyptian are said to be the first to use dermabrasion skin care techniques to improve their skin. They used pumice to remove the rough spots and blemishes and made their skin smooth and soft³⁸. Iverson used hand sand paper to remove traumatic tattoos³⁹. Malner used various grades of silicone carbide sandpapers manually to improve acne scars⁴⁰. Kurtin established wire brush dermabrasion by improving Kromayer’s motorized dermabrasion⁴¹.

In 1985, European dermatologists developed microdermabrasion⁴². It has been used successfully since 1992 to treat acne, fine lines and wrinkles, unwanted pigmentation and other superficial skin damage.

Tsai⁴³ and his colleagues first reported the efficacy of microdermabrasion in 1995. The investigators treated 41 patients with facial scarring with an average of 9 sessions. They used the Harvey 91 microdermabrasion unit (Mattioli, Italy) with a setting of 76 mm Hg. Good to excellent results was observed in all patients.

In another study by Shim et. al.⁴⁴, 14 patients were taken for their prospective

study. Subjective improvement was seen in superficial U scars.

In the work of Mala Bhalla et. al.⁴⁵, a prospective study using MDA was done, which showed an improvement of 5 to 20%.

Mechanism of action⁴⁶

Microdermabrasion produces epidermal and dermal changes through superficial wounding. Part of the superficial epidermis including stratum corneum, surface, surface debris, oil and dirt are removed immediately on direct impact of Al₂O₃ crystals on the skin surface. The resultant superficial wound is then allowed to heal by secondary intention with partial re-epithelialization and remodeling of dermal collagen. The following mechanisms in combination are responsible for the ultimate results.

1. Mechanical disruption of the stratum corneum.
2. Partial epithelialization and stimulation of epidermal cell turnover (production of new cells).
3. Vasodilation of dermal blood vessels and dermal oedema.
4. Stimulation and remodeling of dermal collagen.

Histopathological changes induced by microdermabrasion⁴⁷

- Thinning of stratum corneum
- Increased thickness of epidermis

- Even and regular distribution of melanosomes
- Remodeling of collagen, elastic tissue and dermal oedema
- Vascular ectasia with perivascular mononuclear cellular infiltrate

The Microdermabrasion system and its mechanism⁴⁸

Microdermabrasion unit consists of two systems-projection and suction systems.

Projection system has a compressor generator responsible for the controlled projection of sterile Al_2O_3 crystals.

Suction system creates a vacuum.

There are two designated independent glass/plastic containers along with their flexible tubings for each of these systems that open into handpiece near its tip.

Al_2O_3 crystals used are 100 micron in size, inert, nontoxic, insoluble in water and organic solvents, non-carcinogenic, not known to cause any adverse skin reactions. Instead of aluminum oxide, other crystals like sodium chloride crystals, sodium bicarbonate crystals and magnesium oxide crystals can be used. These are cheaper, but less abrasive and less effective than aluminum oxide.

When the system is activated, the tip of the handpiece gently pulls the skin in and the projected Al_2O_3 crystals abrade the skin surface.

Suction system aspirates the epidermal debris, grime and the used Al_2O_3 crystals. Fresh sterile Al_2O_3 crystals must be used each time and the used crystals discarded.

Skin depth of the microdermabrasion procedure is determined by the strength of the flow of crystals, speed of movement of the handpiece, and the number of passes per anatomic site. Slow movement of the handpiece and a higher number of passes increase the depth of microdermabrasion.

Instead of crystals, diamond tipped devices are available that abrade the skin. Their tips are made of varied sizes and coarseness of diamond chips for different types of skin and levels of resurfacing. The major difference with the crystal free treatment to the crystal is the hygiene.

Indications of microdermabrasion include the following^{49,50}:

- Superficial acne scars
- Comedone extraction.
- Post inflammatory hyperpigmentation
- Superficial to medium rhytides.
- Facial rejuvenation: rough texture, dyschromia, actinic damage.
- Striae

Contraindications^{48,51}

- History of use of isotretinoin within the last six months due to the associated dryness of skin and the possibility of inducing scarring
- Inflammatory acne
- Active bacterial or viral infections
- Active rosacea
- Fragile capillaries, vascular lesions
- Erosions or ulcers
- Keloidal tendency
- Sun burned skin
- Long-term prednisolone or cortisone users
- Raised moles, warts, skin tags
- Vitiligo
- Active uncontrolled or brittle diabetes

Pre-operative work up

- Counseling – explanation of the outcome, side-effects and complications.
- Informed written consent
- Photographs

Procedure^{42,56}

1. The face is cleaned and degreased with acetone.

2. The machine is activated and the pressure is set at ~ 200mm Hg.
3. The skin is stretched with one hand and the hand piece is moved gently in a linear sweeping motion in an outward direction leaving a uniform film of crystals.
4. The entire face is covered segment wise – right cheek → forehead → glabella → left cheek → chin → perioral → nose.
5. Second set of passes are carried out in a direction perpendicular to the first.
6. The procedure is to be carried out for 15-30 minutes.
7. More pressure is applied till pin-point bleeding is seen in cases of deep acne scars.
8. The dust is wiped off and cleaned thoroughly with water.
9. Moisturizing cream is applied.

Side effects^{46,48}

Local side effects are uncommon and transient but include erythema, pain, burning, sensitive skin, photosensitivity, tiger stripes, or diffuse hyper pigmentation. Ocular complications include eye irritation, chemosis, photophobia, and punctate keratitis. Pulmonary complications – pulmonary fibrosis due to inhalation of Al₂O₃

Benefits of microdermabrasion

- Can be used for all skin types and skin tones.
- Easy to perform, less time consuming and requires no special surgical skills.
- No anesthesia is required.
- Safe during pregnancy and lactation.
- Minimal risk of transient hyperpigmentation.
- Overall better patient comfort and compliance

AIM OF THE STUDY

The aim is to study the effectiveness and side effects of CO₂ laser and microdermabrasion in patients with atrophic acne scars of the face after grading them using Goodman and Baron's grading system .

MATERIALS AND METHODS

This study was conducted in the Department of Dermatology, Government General Hospital, Chennai during the period August 2007 – September 2009. A total of 50 patients were enrolled for the study.

Inclusion Criteria

- Patients aged between 15-30 years with both superficial and deep acne scars.
- Patients with only facial lesions
- Emotionally balanced patients with realistic expectation

Exclusion Criteria

- Isotretinoin use for the past six months
- Active herpes simplex
- Keloidal tendency
- Intake of any acne inducing drugs
- Systemic illness e.g. hypertension, diabetes, thyroid problems
- Pregnant and lactating women

Treatment Protocol and Methodology

Patient selected were informed about the nature of the study. A proforma with relevant questions in history, general examination and dermatological examination was made at the outset which was used in the evaluation of the patients selected for the study.

In the initial consultation, this proforma was completed.

A detailed clinical history was taken according to the proforma. History of prior herpes simplex was asked and if present, anti-viral prophylaxis with tablet acyclovir was started. Dermatological examination was done and apart from acne, other dermatological lesions if any were recorded.

Treatment expectations were formulated in discussions with the patient. The following points were explained to the patients.

1. How the treatment works.
2. The potential for adverse effects and care to be taken to avoid them.
3. The length of time before results will be noticed.
4. Post treatment care.

Written consent was obtained from each patient after giving them the above information.

The patients were photographed and assessed clinically at the time of enrolment

to grade the severity of scarring as per the grading system proposed by Goodman and Baron. Only patients with Grade 2 to Grade 4 atrophic scarring were enrolled for the study.

Patients were advised to avoid sun exposure from two weeks prior to the date of treatment and a physical sun screen was prescribed after the procedure. Photographic documentation of the response was done periodically.

CO₂ laser : The configuration of the laser system used in this procedure is as follows:

Ultra CO₂, HM – 30, Manufactured by Dermaindia;

Wavelength: 10, 600nm;

Power to tissue : Ultra pulsed – 0.1W to 3W;

Pulse duration : Ultra pulse - < 300 micro seconds;

Spot size : 100mm handpiece - 1.0mm,

Display : Graphic LCD

Procedure

The patient's facial skin was cleansed and degreased with acetone initially. Thick application of topical anesthesia (EMLA) was done and left for 30-45 minutes before the procedure. The acne scars to be treated were identified and marked with markers. Treatment parameters were programmed in the laser system detailed above starting from

3W, slowly increasing in each sitting by 1W in the ultra pulsed mode. The treatment was given for four sittings at a gap of four weeks. The side effects were noted. Digital photographs were taken before each treatment session and were maintained in the database. Based on the clinical assessment and photographs, improvements were graded. Final assessment was done at the end of sixteen weeks. On objective lines, an improvement of scarring by two grades or more was labeled as ‘excellent’ response while a ‘good’ response meant an improvement by a single grade only. In those patients where the scar grading remained the same after the completion of treatment irrespective of any visible change in the facial scarring the response was labeled as ‘poor’.

The patients were also given a preformed questionnaire at the end of the follow-up period, wherein they were asked to rate the improvement in their scars on a 10-point scale. Questions were asked on depth of scars, side effects, occurrence of new acne lesions, improvement in skin texture and complexion and each were given 2 points. Rating above 6 was graded as ‘excellent response’, rating between 4 and 6 served as ‘good response’ and rating below 4 meant a ‘poor response’. A subjective assessment of the treatment protocol on the part of the patients was also thus obtained.

Microdermabrasion

The configuration of the system used in this procedure is Dermapeel Gold manufactured by Dermaindia with a special imported pump and vacuum control knob.

Procedure

After putting the patient in a comfortable position, the area to be treated was cleansed and degreased with acetone. Treatment parameters were set with pressure ~ 200mm Hg. The handpiece was steadily moved over the target area, applying even pressure and leaving a uniform film of crystals to remove the stratum corneum without affecting the lower skin layers. The session consisted of one to three passes for a period of 15-30 minutes. More pressure was applied till pinpoint bleeding was seen in case of deep acne scars. The dust was wiped off from the surface and cleaned thoroughly with water. After 10 minutes, a moisturizer cream was applied.

Sittings were repeated at two weeks interval for a total of four sittings. The patients were reviewed to assess the therapeutic efficacy and side effects. Digital photographs were taken before each treatment session and were maintained in the database. By clinical assessment and based on the photographs, improvements were graded. Final assessment was done at the end of 8weeks. Overall response was graded similar to the response with CO₂ laser treatment.

OBSERVATIONS

A total of 50 patients were included in the study. 25 patients were taken for CO₂ laser and the remaining patients for microdermabrasion. Of the above, 6 patients dropped out of treatment after the first session.

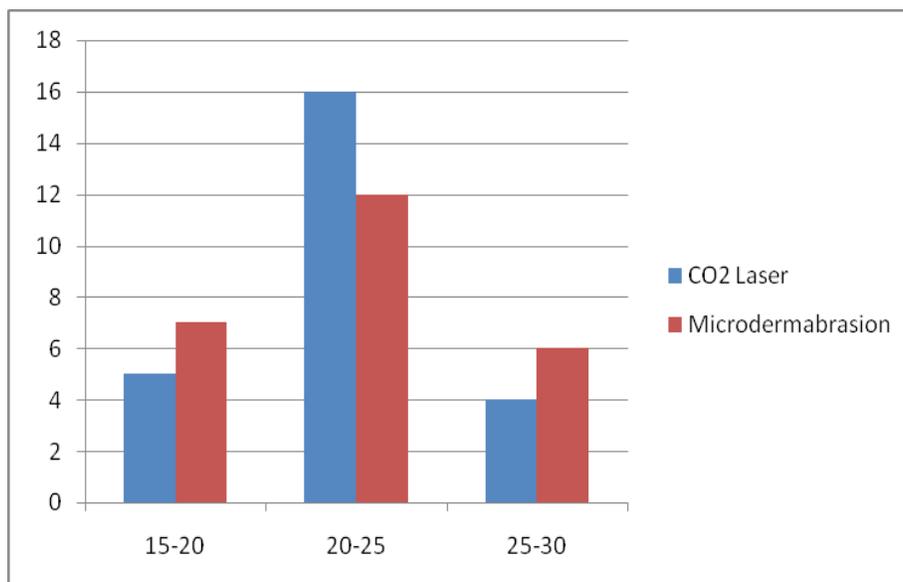
Most of the patients were between 20-25 years with a mean age of 21 years. The youngest patient was a female aged 18 years.

Age distribution of patients

Table 1

| PROCEDURE | AGE (YEARS) | | | Total |
|-----------------------|-------------|-------|-------|-------|
| | 15-20 | 21-25 | 26-30 | |
| CO ₂ Laser | 5 | 16 | 4 | 25 |
| Microdermabrasion | 7 | 12 | 6 | 25 |
| Total | 12 | 28 | 10 | 50 |

Fig. 1



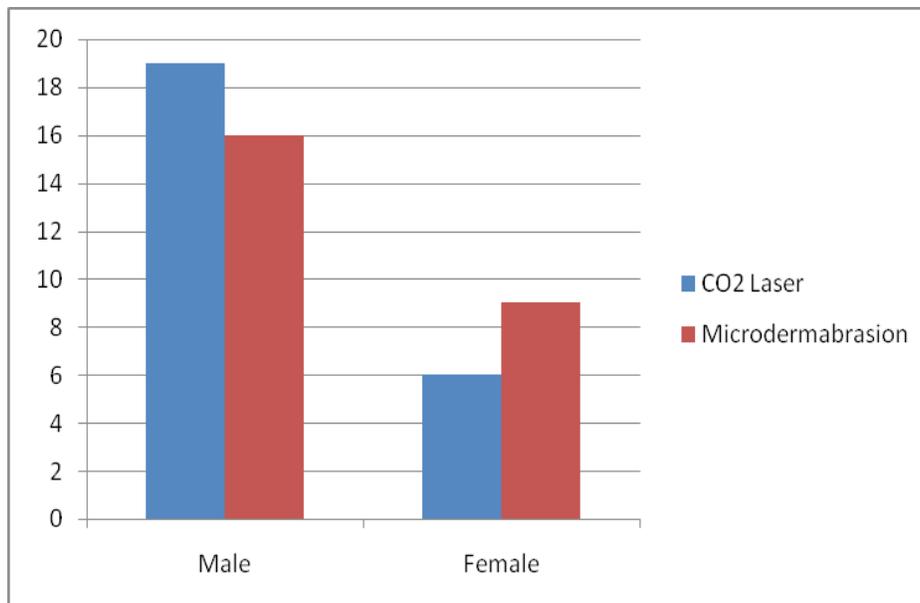
The sex distribution of patients is given in table 2. Male predominance was noted.

Sex distribution of patients

Table 2

| PROCEDURE | Male | Female | Total |
|-----------------------------|-------------|---------------|--------------|
| CO₂ Laser | 19 | 6 | 25 |
| Microdermabrasio | 16 | 9 | 25 |
| n | | | |
| Total | 35 | 15 | 50 |

Fig. 2



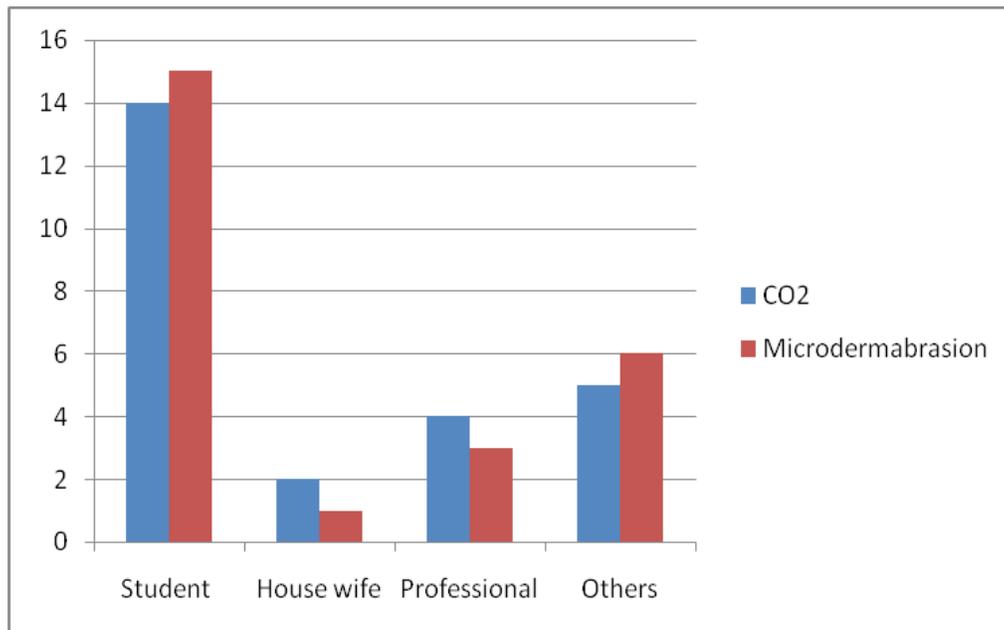
The occupation distribution of patients is given in Table 3.

Occupation distribution of patients

Table 3

| PROCEDURE | OCCUPATION | | | |
|-------------------|------------|------------|--------------|--------|
| | Student | House wife | Professional | Others |
| CO ₂ | 14 | 02 | 04 | 05 |
| Microdermabrasion | 15 | 01 | 03 | 06 |
| Total | 29 | 03 | 07 | 11 |

Fig. 3



Duration of acne scars was found to be 1-8 years with the mean of 3 years.

Table 4. Duration of acne scars

| | | |
|---------------------|-----|-----|
| Duration (in years) | 1-4 | 5-8 |
| No. of patients | 40 | 10 |

More patients had Fitzpatrick skin type 4.

Table 5. Skin types

| | SKIN TYPES | | |
|-------------------|------------|--------|--------|
| PROCEDURE | Type 4 | Type 5 | Type 6 |
| CO ₂ | 14 | 9 | 2 |
| Microdermabrasion | 13 | 10 | 2 |
| Total | 27 | 19 | 4 |

Of the atrophic acne scars, mixed scars were most frequent on the face.

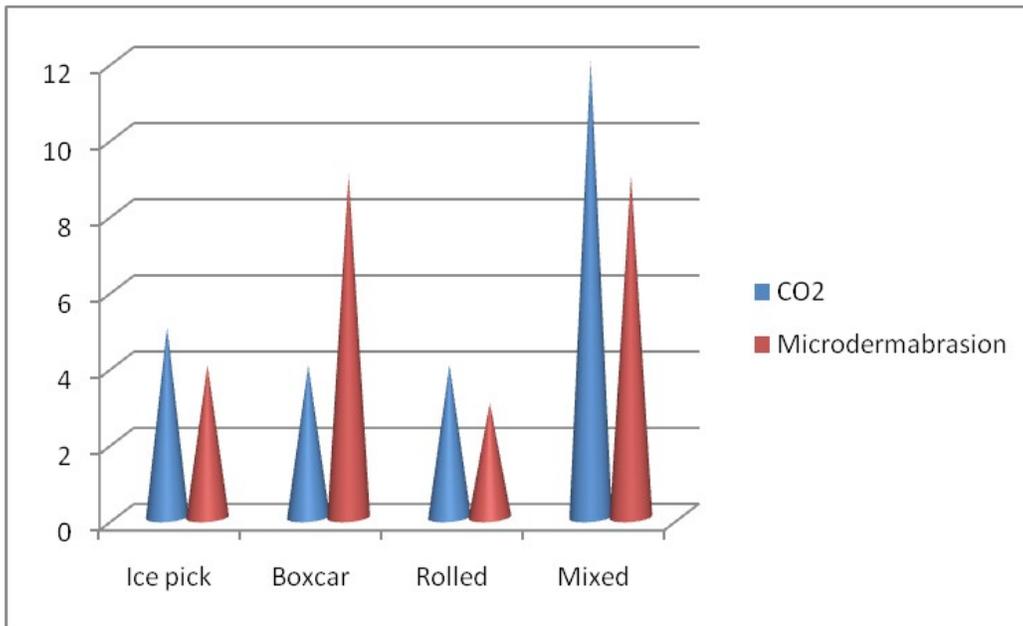
Type of acne scars

Table 6

| | |
|--|------------|
| | ACNE SCARS |
|--|------------|

| PROCEDURE | Ice pick | Boxcar | Rolled | Mixed |
|--------------------------|-----------------|---------------|---------------|--------------|
| CO2 | 05 | 04 | 04 | 12 |
| Microdermabrasion | 04 | 09 | 03 | 09 |
| Total | 9 | 13 | 07 | 21 |

Fig. 4



CO₂ laser

Among the 25 patients treated with CO₂ laser, in our study, only 2 patients dropped out of the study as they could not complete the minimum 4 sittings required for final assessment. The rest of the 23 patients were thus available for evaluation of results at the end of the study period.

All patients tolerated the procedure well and except for a temporary erythema and post-inflammatory hyperpigmentation in one patient, no adverse effect was noted in any patient. No patient reported any interference in his/her daily activities in the immediate post-treatment period and the only change noted in the immediate post-treatment period was a mild crusting that persisted for one or two days. The patients were able to attend to their daily duties on the same day or the next day after the procedure.

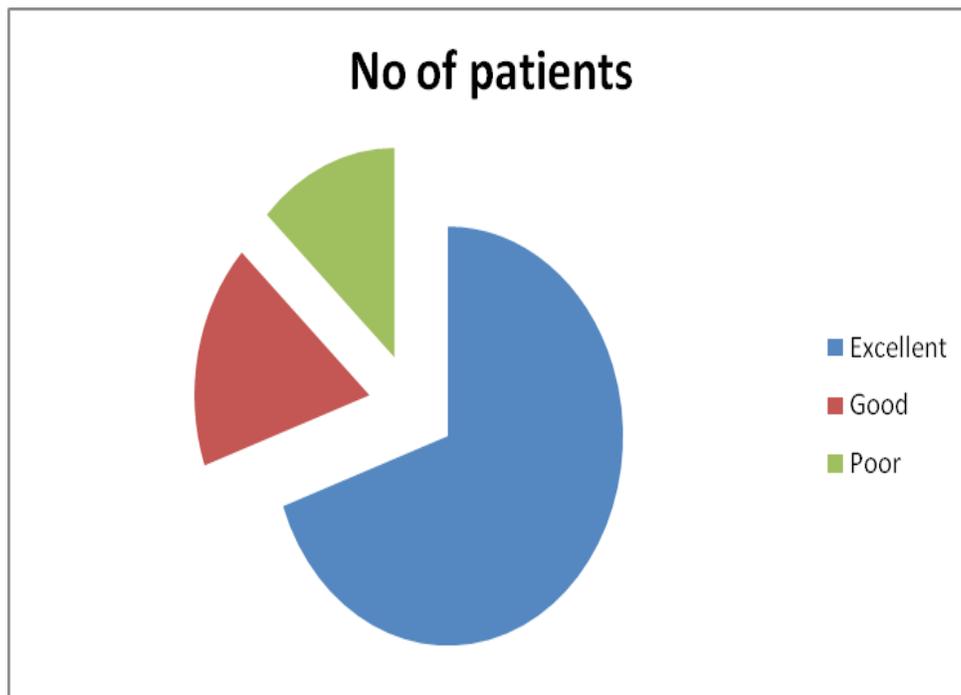
Of the 23 patients who filled the questionnaire at the end of the study period, 16 patients reported the response as 'excellent', 4 patients reported the response as 'good' and only 3 patients reported the response as 'poor'.

Patient satisfaction with CO₂ laser

Table 7

| Satisfaction levels | No of patients | Percentage |
|---------------------|----------------|------------|
| Excellent | 16 | 69.56 |
| Good | 4 | 17.39 |
| Poor | 3 | 13.04 |

Fig. 5



Objective assessment of the patients' scarring at the start of the study revealed Grade 4 scarring in 4 patients, Grade 3 scarring in 16 patients and Grade 2 scarring in 5 patients. The patients who dropped out of the study were suffering from Grade 3 scarring and therefore we had only 14 patients from the original Grade 3 scarring group

for evaluation at the end of the study period.

Of the 4 patients with Grade 4 scarring, only 2 patients achieved an 'excellent' response on objective assessment. In these patients the grading of scars at the end of treatment could be reduced to Grade 2. In one patient, the scar grading was reduced to third grade and thus the response in this patient was labeled as 'good'. In another patient, no significant change could be observed in the severity of scarring and the response was thus labeled as 'poor'.

Subcision was done prior to the CO₂ in patients with grade 3 acne scars in order to release the tethering of fibers.

In 14 patients with Grade 3 scarring, an excellent response was similarly noted in 8 patients (reduction to Grade 1 or less), 4 patients achieved a good response while 2 patients had a poor response to treatment.

In patients with Grade 2 scars 4 showed excellent responses to treatment and one showed poor response.

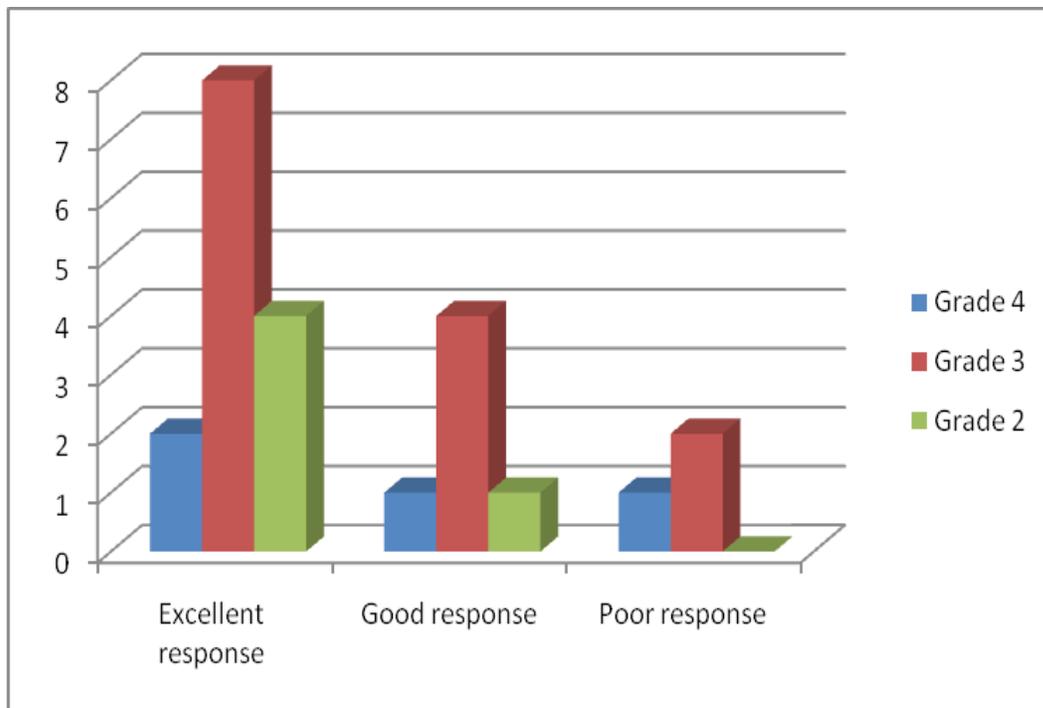
CO2 laser showed excellent response in grade 3 acne scars

Response with CO₂ laser

Table 8

| Grade of scars | No. of patients | Excellent response | Good response | Poor response |
|----------------|-----------------|--------------------|---------------|---------------|
| 4 | 4 | 2 (50%) | 1 (25%) | 1 (25%) |
| 3 | 14 | 8 (57.14%) | 4 (28.57%) | 2 (14.28%) |
| 2 | 5 | 4 (80%) | 1 (20%) | -- |
| Total | 23 | 13 (56.52%) | 7 (30.43%) | 3 (13.04%) |

Fig.6



Thus, overall, 13 out of the total 23 patients (56.52%) showed an excellent response to the procedure while 7 others achieved a good response (30.43%). Only 3 patients (13.04%) out of the total of 23 failed to show a significant response to treatment.

Correlating the response rate with the grade of scarring present, an excellent response rate was achieved in the majority of patients with Grade 2 and 3 scarring. However, in patients with Grade 4 scarring, only 2 out of the 4 patients had excellent response, while in 1 patient, the response was good. However, because of only a few patients with Grade 4 scars in the present study, the comparative results could not be tested for their statistical significance.

Correlating the response with the morphological type of scarring present, we found a good to excellent response in rolling and boxcar scars while pitted scars showed only poor improvement.

Microdermabrasion

Among the 25 patients treated with microdermabrasion in our study, only 4 patients dropped out of the study as they could not complete the minimum 4 sittings required for final assessment. The rest of the 21 patients were thus available for evaluation of results at the end of the study period.

All patients tolerated the procedure well, except for a temporary erythema and

edema which persisted for 3-4 hrs. No patient reported any interference in his/her daily activities in the immediate post-treatment period

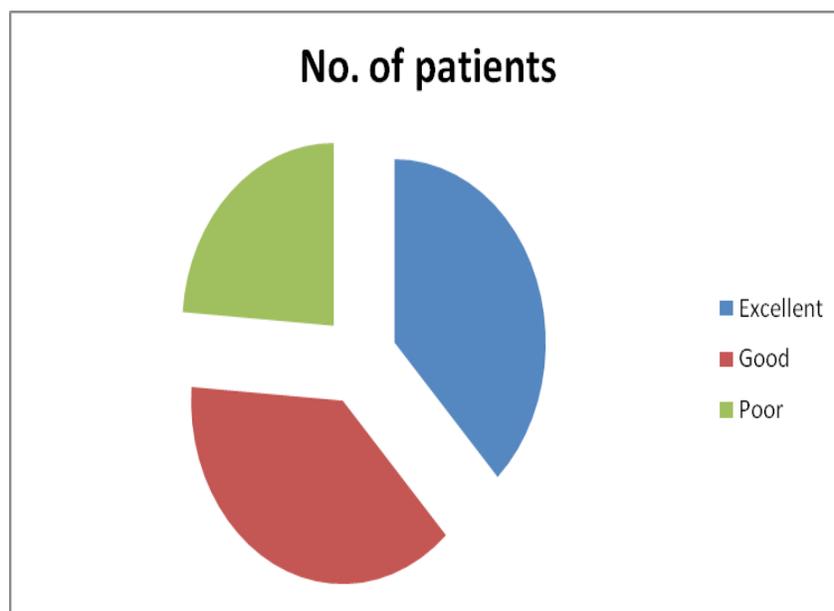
Of the 21 patients who filled the questionnaire at the end of the study period, 8 patients reported the response as 'excellent', 8 patients reported the response as 'good' and only 5 patients reported the response as 'poor'.

Patient satisfaction level with Microdermabrasion

Table 9

| Satisfaction levels | No. of patients | Percentage |
|---------------------|-----------------|------------|
| Excellent | 8 | 38.09 |
| Good | 8 | 38.09 |
| Poor | 5 | 23.80 |

Fig. 7



Objective assessment of the patients' scarring at the start of the study revealed Grade 4 scarring in 2 patients, Grade 3 scarring in 20 patients and Grade 2 scarring in 3 patients. The 2 patients who dropped out of the study were suffering from Grade 4 scarring and remaining to with grade 3 scarring therefore we had only 2 patients from grade 4 and 16 patients from the original Grade 3 scarring group for evaluation at the end of the study period.

Both the patients, with grade 4 scarring showed poor response.

In 16 patients with Grade 3 scarring, an excellent response was seen in 4 (25%) patients (reduction to Grade 1 or less), 9 (56.25%) patients achieved a good response while 3(18.75%) patients had a poor response to treatment.

In patients with Grade 2 scars one showed an excellent response to treatment.

Thus, overall, 5 out of the total 21 patients (23.8%) showed an excellent response to the procedure while 11 others achieved a good response (52.3%). Only 5 patients (23.80%) out of the total of 21 failed to show a significant response to treatment.

Correlating the response rate with the grade of scarring present, a good response rate was achieved in the majority of patients with Grade 2 and 3 scarring.

Correlating the response with the morphological type of scarring, we found a good response in rolling and boxcar scars while pitted scars showed only poor improvement.

Microdermabrasion showed good response in grade 3 acne scars

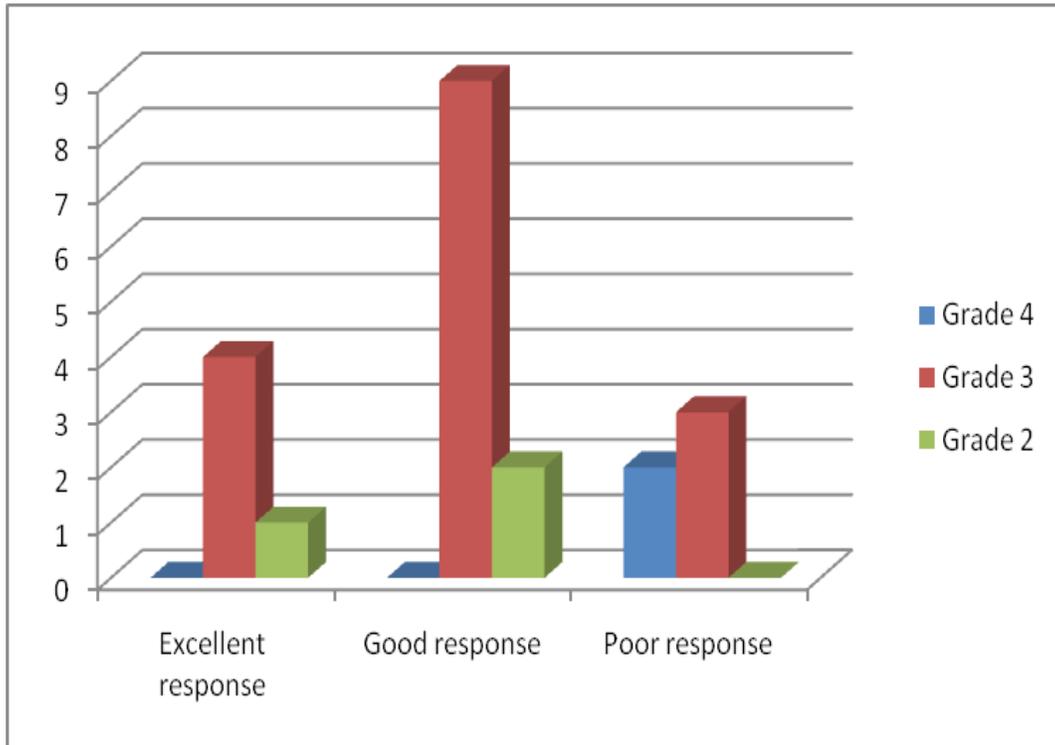
Response with Microdermabrasion

Table 10

| Grade of scars | No. of patients | Excellent response | Good response | Poor response |
|-----------------------|------------------------|---------------------------|----------------------|----------------------|
| 4 | 2 | -- | -- | 2 (100%) |
| 3 | 16 | 4 (25%) | 9 (56.25%) | 3 (18.75%) |

| | | | | |
|-------|----|------------|-------------|------------|
| 2 | 3 | 1 (33.33%) | 2 (66.66%) | -- |
| Total | 21 | 5 (23.80%) | 11 (52.38%) | 5 (23.80%) |

Fig. 8



DISCUSSIONS

Atrophic facial acne scars occur frequently, most often as a consequence of severe acne during the teenage years. Many patients seek treatment for the resultant disfigurement not only because of the obvious variations in skin texture, but also for the limitations placed on social interaction, self-esteem, and daily activities.

In our study, most of the patients were between 20-25 years with a mean age of 21 years. The mean age was 24.6 in the study done by Apfelberg et al⁴.

Comparing with the survey done in France² in which there was no gender difference, in our study males predominated. Probably since the acne is more severe in boys than in girls, this may have resulted in severe acne scars.

In our study, 40 patients showed a mean duration of 3 years.

Most of the patients had a mixed type of acne scars compared to the study by Layton et. al⁵. which showed more of ice pick scars.

The choice of treatment of post acne scars depends both on the morphological types as well as severity of each scar present on the face¹².

In the study by Alster et al., post acne scars were not graded. Only photographs of the patients were used to assess the severity. But in our study the post acne scars were graded into 4 different grades depending on Goodman and Baron as was done in a study

by Imran Majid et al. to analyze the effect of microneedling.

In Alster et al study, improvement in the scarring was assessed using only photographs of patients. No definition was given. Mean overall improvement was based on subjective improvement. In our study, improvement in scarring was assessed objectively both clinically as well as with photographs noting the grade improvement, if any; also taking into consideration patient subjective improvement.

A study done by Alster et al.²⁴ for 50 patients showed scar improvement of 70-90% with a mean of 81.4% with co2 laser. In another study done by Bernstein et. al. 50-75% showed improvement. In our study, CO₂ laser showed an excellent response in 56% while in the remaining, 30% and 13% showed good and poor response respectively. Thus, on an overall basis, a good to excellent response was achieved in 20 patients out of 23 (86%).

In Alster's study, improvement was not noted for individual scar types, but on overall basis. In our study excellent response was seen in rolling and boxcar scars with co2 laser.

The work of Alster et. al. showed that, 36% of patients had transient hyperpigmentation following Co2 laser that resolved in 3 months. Fourteen per cent of patients developed milia, but there were no bacterial and fungal infections. In our study, most of the patients noted immediate post treatment mild crusting that persisted

for one or two days. However , there was no post inflammatory pigmentation except in one patient who had to discontinue the treatment. The procedure was tolerated well in our study.

In our study, patients with rolling scars were randomly selected and subjected to subcision prior to CO₂ laser. These patients showed better improvement when compared to CO₂ laser alone. Side effects following subcision were treatment site edema and haematoma which subsided within 2-3days.

Tsai⁴³ and his colleagues first reported the efficacy of microdermabrasion for treating acne scars in 1995. The investigators treated 41 patients with facial scarring with an average of 9 sessions. They used the Harvey 91 microdermabrasion unit (Mattioli, Italy) with a setting of 76 mm Hg. Good to excellent results was observed in all patients. In another study by Shim et. al.⁴⁴, 14 patients showed subjective improvement in superficial U scars. In the work of Mala bhalla et. al.⁴⁵, microdermabrasion showed an improvement of 5 to 20%.

In our study, with a total of 25 patients, acne scars were graded according to Goodman et. al⁹. Excellent response rate was achieved in grade 2 and 3 scarring. 5 out of 21 patients (23.8%) showed excellent response. Among the remaining 52% and 23% showed good and poor responses respectively.

There was an immediate feel good effect with microdermabrasion due to dermal

odema (plumping effect) which was appreciated by all the patients as improvement due to visual impact.

The temporary benefit seen immediately after one or two sittings of microdermabrasion disappeared once the dermal odema subsided with reappearance of acne scars

Side effects of microdermabrasion were transient included mild discomfort during the procedure and slight erythema and tingling sensation for 1 to 2 days after procedure were noted in our study similar to other studies.

With CO₂ laser procedure, grade 2 and grade 3 scars, especially rolling and boxcar scars, showed excellent improvement, while with microdermabrasion, grade 2 and 3 scars showed only a good response. Statistically there is a significant difference between the CO₂ laser and Microdermabrasion at 5% level ($P < 0.05$).

Both the procedures were not effective for grade 4 scars i.e. ice pick scars and severe boxcar scars.

By subjective assessment, for all grades of acne scars, patients were more satisfied with CO₂ laser in comparison with microdermabrasion.

Patients were comfortable with both CO₂ laser and microdermabrasion and came for regular follow up during the study period.

In CO₂ laser, the results were seen only after 2 to 3 sittings with patients with

grade 2 and grade 3 acne scars while after four sittings improvement was seen in grade 4 acne scars. In microdermabrasion, though subjective improvement was noted immediately, objective results were seen only after 4 sittings.

It may not be sufficient to assess the outcome with only 4 sittings of procedures as the maximum beneficial effect may take 6 to 12 months for full collagen remodeling to evolve.

CONCLUSIONS

- CO₂ laser is a highly versatile laser and is useful for treating acne scars.
- CO₂ laser showed excellent response in grade 2 and 3 acne scars.
- CO₂ is not effective for ice pick scars and severe boxcar scars.
- CO₂ laser with ultra-pulse mode showed minimal side effects.
- Subcision prior to the CO₂ laser procedure showed better improvement when compared to CO₂ laser alone in patients with rolling acne scars.
- Microdermabrasion showed good response in grade 2 and 3 scars.
- Side effects due to microdermabrasion procedure were transient.
- Statistically there is a significant difference between the CO₂ laser and Microdermabrasion at 5% level ($P < 0.05$).
- Treatment of post acne scars requires multiple therapeutic modalities as single modality alone is not hundred percent effective.

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PROFORMA

Serial No.

Date:

Name

Age

Sex

Occupation

Address

O. P. No.

Complaints

History of presenting illness

Site

Duration

Evolution

Associated symptoms if any

H/o

Drug intake: Steroids, Antitubercular drugs, anti epileptic drugs.

Exposure to cutting oils, coal tar oils

Local application of any greasy preparation

Excessive hair growth

Recent use of isotretinoin

Active cutaneous bacterial and viral infection

Keloidal tendency

Photosensitivity

History suggestive of collagen vascular disorder

Previous Treatment History: On going UV exposure previous radiation therapy, laser resurfacing, chemical peel, dermabrasion

Allergy History

Past History – Diabetes, Hypertension, Auto immune disorder, Skin cancers

Family History – similar complaints, Keloidal tendency, Diabetes, Hypertension

Personal History – Smoking, alcohol

Menstrual History

General Examination

Systemic Examination

Dermatological Examination

Note

Skin type

Type of acne scar

Grade

Distribution

Others – Evidence of active acne lesions, pigmentation, increased hair growth, any raised lesion, telangiectasia, and tattoos.

CO₂ laser

| No. of sitting | Mode | Power | Time on | Time off | Subjective response | Objective response | Side effects |
|-----------------------|-------------|--------------|----------------|-----------------|----------------------------|---------------------------|---------------------|
| 1 | | | | | | | |
| 2 | | | | | | | |
| 3 | | | | | | | |
| 4 | | | | | | | |

Microdermabrasion

| No. of sitting | Subjective response | Objective response | Side effects |
|-----------------------|----------------------------|---------------------------|---------------------|
|-----------------------|----------------------------|---------------------------|---------------------|

