

Manuscript ID
DOIZUMJ-2003-1777 (R3)
10.21608/zumj.2020.26238.1777

ORIGINAL ARTICLE

Fractional CO₂ Laser in Treating Post Traumatic Scars

Mona Mostafa Mohamed¹, Mahmoud Yousry Abdel-Mowla², El-Sayed M. Galal Khater²¹Dermatology, Venereology and Andrology Department, Zagazig University, Egypt²Dermatology, Venereology and Andrology Department, Zagazig University, Zagazig, Sharkia, Egypt

Corresponding author

Mona Mostafa Mohamed Mostafa

E.mail :

mm7560820@gmail.com

Submit Date 2020-03-30

Revise Date 2020-05-10

Accept Date 2020-05-14

ABSTRACT

Background: Scars are anomalous reactions to wounds in predisposed individuals. They occur in predisposed individuals after any form of wound and skin inflammation. Various modalities were used, and depending on the type of wound. Therefore, the aim of this study was to evaluate the efficacy and safety of fractional CO₂ laser in treatment of post-traumatic scars. **Material and Methods:** This study included 20 patients (4 males and 16 females) affected by post-burn scars as well as post-traumatic atrophic scars were treated with monthly sessions of fractional CO₂ laser treatment. Between through procedure and 3-4 weeks after the final procedure, the patients and investigators rated side effects as well as changes in texture, atrophy and overall appearance satisfaction on a quartile scale. Comparison was made before / after ratings. **Results:** Patient's response to treatment was assessed clinically as well as improvement of scars by comparing the photographs taken before treatment with those taken 6 months after the last treatment session. Treatment outcome and patient satisfaction were assessed on a quartile grading scale and scored individually from 0 to 4. A mean of six treatments per scar were required and all patients, followed up for 3 months after the last treatment, had optimum results and no recurrence. Response to treatment was excellent in 65%, very good in 15% patients, and good in 20% patients.



Conclusion: Fractional CO₂ laser treatment represents a safe, well-tolerated, effective, and promising treatment modality for post-traumatic, post-burn and post-inflammatory scars, with minimal side effects.

Keywords: Post-traumatic scars, Fractional CO₂, Laser.

INTRODUCTION

Post-traumatic scar is a common skin condition that affects both male and female, which has a negative impact on the individual who acquires it and is correlated with physical and psychological distress, particularly if the painful scar is reported on the face or other uncomfortable place. Scars are fibrous tissue (fibrosis) areas which replace normal skin after injury. Scarring is a common part of the healing process except for very small lesions because it results in a degree of scarring (after an injury or surgery)[1].

There are many therapies available; but many of these types of treatment have their own drawbacks. In the past decades, many lasers and light sources have been tested, and injuries have been shown to change. The ablative lasers were reported to have

side effects such as transient erythema, oozing, crusting, ulceration and burning discomfort. There can also be several long-term adverse effects like permanent hypopigmentation, hyperpigmentation and permanent scarring[2].

Fractional CO₂ laser has been widely used for the treatment of atrophic facial acne scars and for skin rejuvenation [3].

The present study was aimed to assess the, safety and efficacy of fractional CO₂ laser in the treatment of post-traumatic scars.

MATERIALS AND METHODS

This interventional study was carried at Laser unit at Dermatology, Venereology and Andrology department, Zagazig University Hospitals. All patients were recruited from Dermatology, Venereology and Andrology outpatient clinics of

Zagazig University Hospitals in the period from April 2017 to January 2018. The present study included 20 patients aged 12-35 years old with different skin types suffering from different types of post-traumatic scars as hypertrophic scars, keloid scars, atrophic scars and burn scars in the face and upper limb. Patients included in this study were no therapy given for scars during the last three months e.g. (Retinoids, Topical creams...). No concomitant cosmetic procedures are allowed between the laser sessions and no topical drugs were prescribed except sunscreens and topical antibiotic creams in the post procedure period.

After exclusion of pregnant patients, Patients on immunosuppression, patients with herpes simplex history and patients with infected post traumatic scars, Written Informed consent was taken from the patient to participate in the study. Approval for the research was received from the Department of Internal Medicine, Zagazig University Hospitals, following approval by the Institutional Review Board (IRB).

This research was conducted under the World Medical Association Code of Ethics (Helsinki Declaration) for human interaction studies.

Methods: Patients were subjected to history taking regarding age and sex, history of present dermatological disease: including, onset, course, duration, site, and history of previous treatment for the disease, history of trauma or surgery causing the atrophic scars, history of associated other dermatological diseases, and history of systemic diseases and drug intake. Local examination was cared for scars to determine the type of the scars and its severity according to quartile grading scale evaluation [4]. Photographs are taken before and after laser sessions to evaluate the results. The clinical assessment by means of clinical progress and patient satisfaction was objectively based on clinical photography before treatment and one month after last laser treatment session. The taken photographs for each patient pre and after each session were evaluated by the same non biased physician in the same order.

A physician evaluator also assessed the final treatment outcomes by comparing pretreatment and post treatment clinical photographs using a quartile grading scale; grade 0=no improvement, grade 1 = minimal improvement (1 – 25 % improvement), grade 2=moderate improvement (26%- 50% improvement), grade 3 = marked improvement (51%-75% improvement), grade 4 = near – total improvement (76%-100% improvement) [4]. The patients were asked to scale their subjective satisfaction with the treatment on a quartile grading scale; grade 0 = no satisfaction, grade 1 = minimal satisfaction (1– 25

%satisfaction), grade 2=moderate satisfaction (26%-50% satisfaction), grade 3 = marked satisfaction (51%-75% satisfaction), grade 4 = near – total satisfaction (76%-100% satisfaction) [4].

All the patients were treated monthly with fractional CO₂ Laser. Eight sessions for each patient. Treatment was performed using ablative CO₂ fractional laser (Kes), China marketed, as a monotherapy, with a wavelength of 10,600 nm, energy in 12w and treatment density of 0.6mm MTZ/cm² in all patients. Laser waves discharge heat into the dermis and the epidermis stimulating dermal collagen and producing fractional photothermolysis of tissue in the form of multiple coagulated columns surrounded by separating uncoagulated tissue. These coagulated columns known as micro thermal zones.

Therefore, the skin receives the laser shots, and the operator must avoid overlapping, as this activity can increase the laser potency and cause skin damage. Higher thermal damage occurs when a certain region is treated with several overlapping, less healthy skin is left behind, thereby elevating the risk of scar formation. Each morphological form of the scars was handled in a different way. The laser parameters had been modified according to the skin type and scar site and was changed for the same patient in each visit according to the scar response (table 1). The session takes about 10-15 minutes to be completed. We proposed eight sessions, for 3-4 weeks apart.

Directly after the laser section, the skin has erythema and swelling due to vaporization of the tissue and an exuberant serous, so a moisturizing cream was added directly to the skin. The patients were instructed to avoid direct sun exposure for the next 4-5 days after each procedure and a topical non occlusive antibiotic cream formulation e.g fusidic acid was applied twice daily throughout the following 3 days after laser session. The patients were instructed to gently wash their face with glycerin soaps. Even advised the patients to use a wide-spectrum sunscreen every morning 30 minutes before going out and repeating every two hours. The doctor must make sure that the patients are conscious of rehabilitation, the steps need to be taken at home and how expectations can be handled. For the first week following the laser session, the patients were followed up by clinic visit, telephone or e-mail for adverse effects or complications. If present, erythema, edema, and hyperpigmentation were reported and assessed at each time span. The final therapeutic effect after the last laser treatment was measured at 3 months.

Cases : Female patient, 25yrs old, skin type II with post-traumatic scar .Case 1.

Male patient, 22 yrs old, skin type III with post-traumatic scar. Case 2.

Statistical analysis: All data for windows (SPSS Inc., Chicago, IL, USA) were collected, tabulated, and statistically analyzed using SPSS 24.0. Using the Shapiro Walk method the data was checked for normal distribution. Qualitative data is interpreted as relative frequencies and percentages. The exact Chi square test (χ^2) and Fisher were used to measure the difference between the qualitative variables as shown. Quantitative data for parametric and median data and range for non-parametric data were expressed as mean \pm SD (Standard deviation). For parametric and non-parametric variables, independent T test and Mann Whitney test were used to measure difference between quantitative variables in two classes, respectively. Kruskal Wallis test was used for Comparing numerical variables, it is the non-parametric equivalent of ANOVA, is used if the data cannot be assumed to have a normal distribution. All statistical differences were two tails with the P-value of 0.05 indicates a significant difference, $p < 0.001$ indicates a extremely significant difference while $P > 0.05$ indicates a non-significant difference.

RESULTS

The 20 patients included 4 males and 16 females with ages ranged from 12 to 32 years old, with a mean of 21.05 ± 5.54 years old. We found an excellent agreement between overall patients' satisfaction with appearance and Post-treatment therapeutic response. We also found a statistically significant difference between responses after treatment with fractional CO₂ laser in relation to

age, duration of post-traumatic scars, type of skin and side effects as illustrated.

Fifty-five (55%) of the studied patients had skin type II ,only 3 (15%) of them had skin type IV, while skin type III was represented in 6 (30%) of them and duration of post traumatic scars among the studied patients ranged from 1 month to 6 months, with a mean of 2.72 ± 1.75 months, (80%) of the studied patients suffered from atrophic post traumatic scar, while 10% of them suffered from keloidal post traumatic scar and (95%) of the studied patients have post traumatic scars at face. Table 2

Patient satisfaction: (grade 2, 26–50% = satisfied; grade 3, 51– 75% = very satisfied; grade 4, 76–100% improvement = extremely satisfied). **Therapeutic response:** (fair, 26–50% = moderate improvement; good 51-75%= marked improvement; and excellent, >75% = near-total improvement). Table 3

Patients were treated in eight sessions with fractional CO₂ laser at a 2-weeks interval, and side effects after fractional CO₂ laser among the studied patients was reported as (55.0%) of the studied patients didn't complain of any side effects and about half of them (45%) complained of Transient erythema which resolved within 3-4 days, other side effects as superficial Crust formation which lasting for 4-6 days occurred in (25%), as illustrated in the figure. Figure 1

There was a statistically significant difference between response after treatment with fractional CO₂ laser in relation to age of the studied patient, scar duration ,skin types, side effect and excellent agreement between overall patients' satisfaction while no difference in relation to sex. Table 4

Table (1): Parameters of fractional CO₂ laser for patients with post traumatic scar

Parameters	Atrophic scar in the face	keloidal scar in the face	scar in body
Energy (mj)	20-30	30-50	30-50
Power (w)	12	12	12
Duration (min)	1.2	2.0	3.0
Interval (ms)	1.0	1.0	1.0
Density (mm)	0.6	0.6	0.6
Scan mode	random	random	Random
Output wavelength (nm)	10.600	10.600	10.600

Table (2): Skin and Scars features of the patients

Variable	Studied patients (n=20)	
Skin types n (%)	II	11 (55)
	III	6 (30)
	IV	3 (15)
Scars Duration (months) Range	1 - 6	

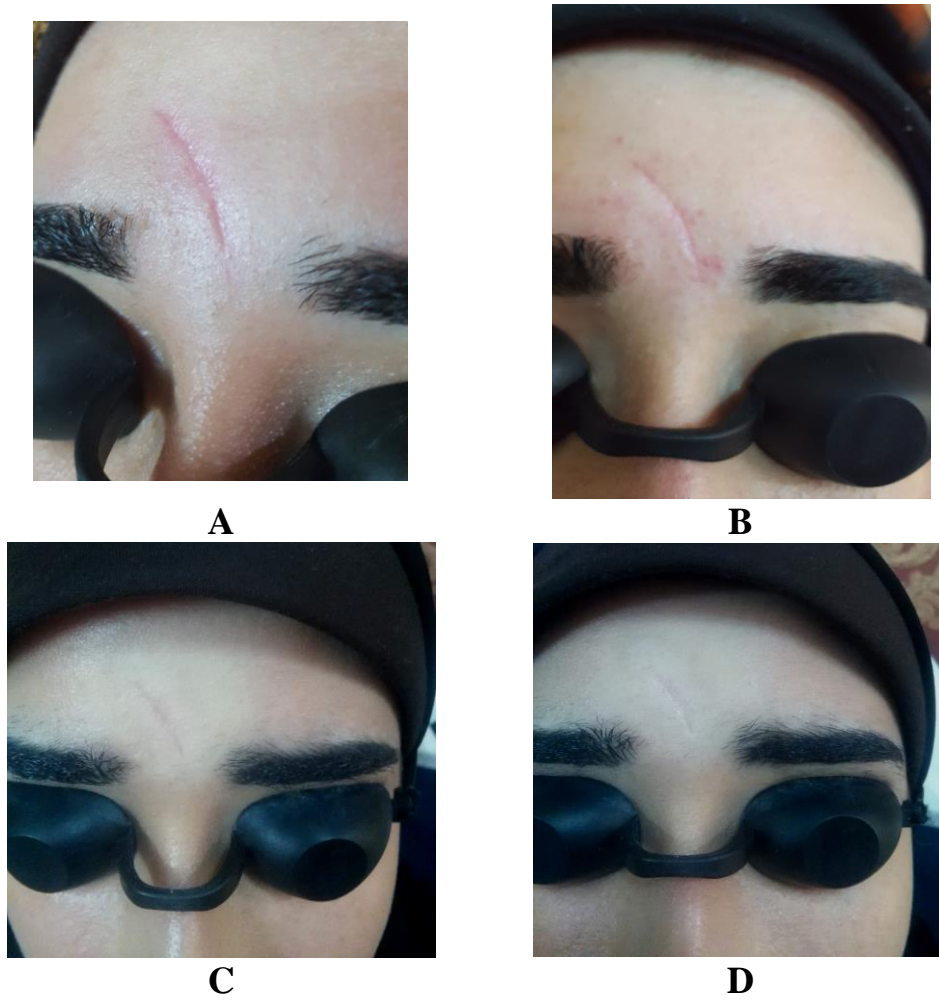
Variable		Studied patients (n=20)
Scars type n (%)	Atrophic	16 (80)
	Keloid	2 (10)
	Burn	2 (10)
Scars site n (%)	Face	19 (95)
	Upper limb	1 (5)

Table (3): Patient satisfaction and therapeutic response among the patients

Response		Studied patients (n=20)
Patient satisfaction n (%)	Extremely satisfied	12 (60)
	Very satisfied	4 (20)
	Satisfied	4 (20)
	Not satisfied	0
Therapeutic response n (%)	Excellent	13 (65)
	Very good	3 (15)
	Good	4 (20)
	poor	0

Table (4): Patients’ characteristics between different therapeutic responses after treatment with fractional CO₂ laser.

		Good (N=4)	Very (N=3)	Good (N=13)	P
Age (years)					.001
Mean ± SD		27.75 ± 3.86	26.33 ± 1.52	17.71 ± 3.32	
Female n (%)		3 (75)	3 (100)	10 (76.9)	.641
Scar duration (months)					.006
Mean ± SD		5.62 ± .47	3 ± 1.73	1.76 ± .69	
Patient satisfaction, n (%)	Satisfied	4 (100)	--	--	<0.001
	Verysatisfied	--	3 (100)	1 (7.7)	
	Extremely satisfied	--	--	12 (92.3)	
Skin types, n (%)	II	1 (25)	3 (100)	7 (53.8)	.002
	III	--	--	6 (46.2)	
	IV	3 (75)	--	--	
Side effects	No side effects	--	--	11 (84.6)	.001
	Transient erythema	4 (100)	3 (100)	2 (15.4)	.001
	Crust	4 (100)	1 (33.3)	--	<0.001



Case 1. Female patient, 25yrs old, skin type II with post-traumatic scar. A) before laser therapy. B) After three sessions (score2 = moderate improvement). C) After five sessions (score 3= marked improvement). D) After treatment (score 4 = near total improvement).

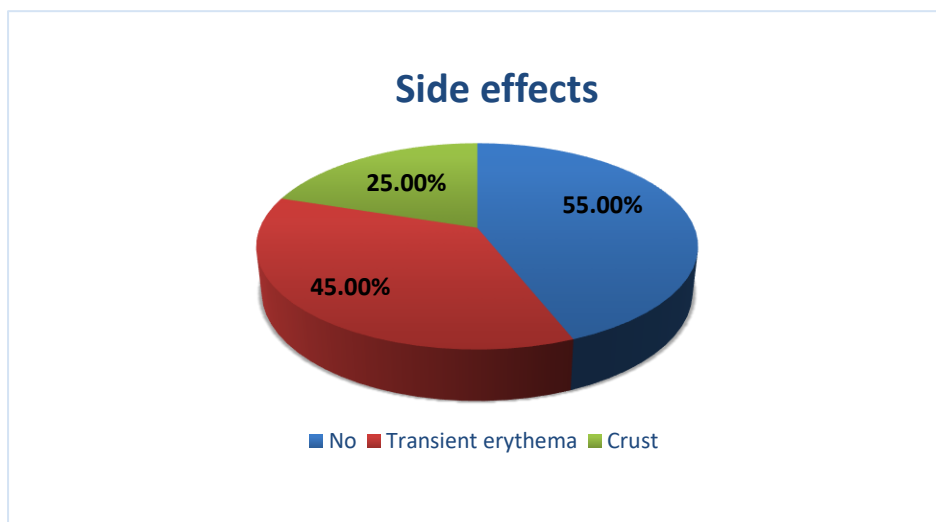
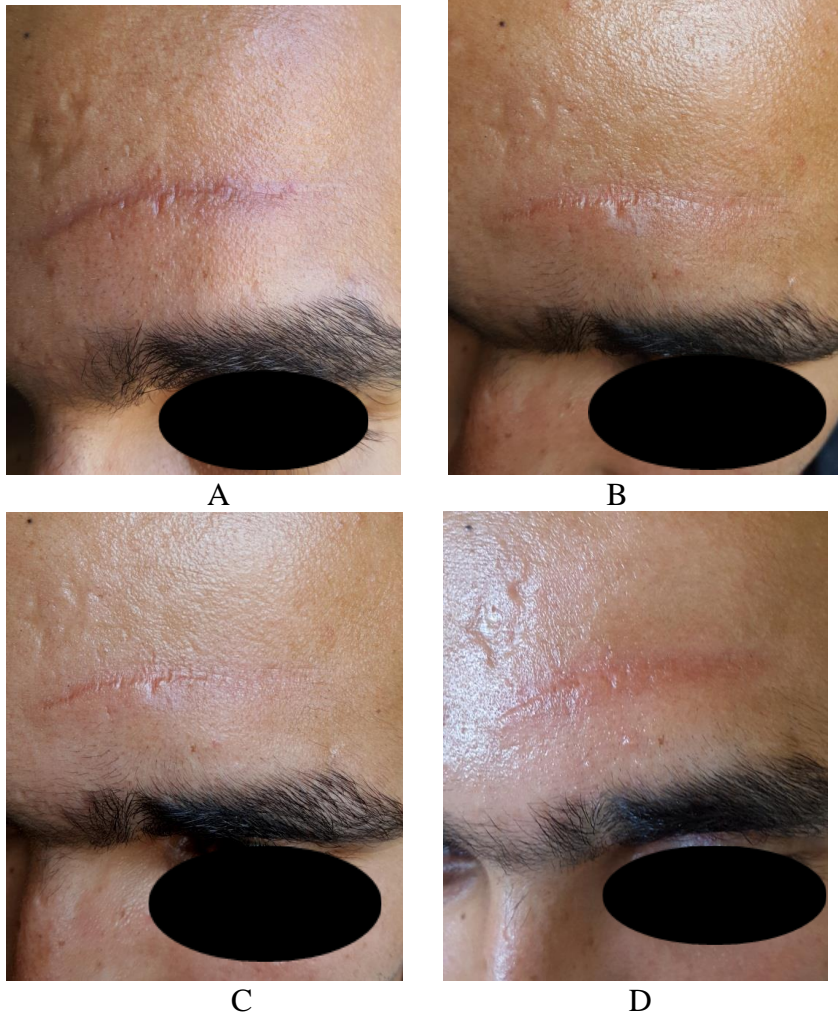


Figure 1. Side effects



Case 2. Male patient, 22 yrs old, skin type III with post-traumatic scar. A) Before laser therapy. B) After three sessions (score 1=minimal improvement). C) After five sessions (score 2=moderate improvement). D) After treatment (score 3=marked improvement).

DISCUSSION

Post-traumatic scar is a common skin disorder that associated with physical and psychological distress especially if the unpleasant scar is logged on the face or another inconvenient location. Early and effective treatment of post-traumatic scar is the best mean to minimize the physical disfigurement occur [5].

Post-traumatic scar therapy is creating a problem for patients and dermatologists alike. Every scar has a specific structure which requires a personalized approach. The selection of an approach to treatment is based upon factors such as the depth of the incision or wound, location of the wound on the body, patient preference, side effects, cost, and treatment availability. A multimodality approach for post-traumatic scar treatment is usually necessary to achieve the best cosmetic results [6].

Fractional resurfacing is a novel variation on the selective photothermolysis principle, where regulated distance, depth, and density zones are generated in microscopic treatment. This managed areas of thermal heating and tissue damage are surrounded by spare areas of viable epidermis and dermis which enable the microscopic treatment areas to be repaired quickly [7].

More research investigating NAFL's efficacy in the treatment of these various forms of wounds may help guide potential care. Patients who receive NAFL treatment for post-traumatic scarring experience 2 to 4 days of severe erythema and crusting that normally improves within a week, 26 to 50 percent improvement in wounds and high tolerability [8].

In our study, a positive response with either very good or excellent results was documented in 16 patients corresponding to 80% of the patients including in this study. Excellent response was

observed in a total of 13 patients (65.0%). Three patients (15.0%) showed a very good response while 4 patients (20%) showed good response. Majority of patients in this study were of excellent response with 65.0% improvement of post-traumatic scars after laser sessions.

Results of this study were consistent with that reported by **Majid and Imran, [9]** who had reported positive response was observed in 84% patients. Of these, 60% of patients achieved excellent response was achieved on the quartile grading scale. While about 24% of patients achieved good response, three patients were able to achieve >75% improvement. Improvement in scar morphology and texture in the study group.

Subjectively also, majority of the patients were satisfied with the results obtained after the end of treatment schedule. Adverse effects seen were not significant and none of the enrolled patients had any long-term or permanent side effects from the procedure.

Our findings were also consistent with those stated by **Ibrahim et al.[4]** those his research included 13 patients with atrophic and hypertrophic scars with surgical and post-traumatic scars abroad, and patient age ranged from 13 to 40 years. The research covers 9 males and 4 females. Of the 13 patients treated with 1540 nm non-ablative fractional laser, 2 patients had an improvement of 1-25%, 5 patients had an improvement of 51% -75% and one patient had an improvement of 76% -100%. Several patients judged the wounds to get worse from diagnosis.

Side effects during the procedure were mild to moderate pain and mild to moderate post-treatment erythema and edema which resolved within 3-5 days. There were no other harmful conditions, such as hyperpigmentation, hypopigmentation, blistering or scars worsening.

Fractional CO₂ laser have been found to reduce the scar size and volume in post-traumatic and surgical scars and are more effective for atrophic scars than hypertrophic scars. A study conducted by **Wiess et al.**, demonstrates a 38.0% mean reduction of volume and 35.6% mean reduction of maximum scar depth in non-acne atrophic scars due to trauma and surgery [10].

Twenty patients underwent fractional laser therapy using a fractional CO₂ laser system in the present study; there were more females (80 percent) than males (20 percent); Significant review of our findings showed no significant association between the patients clinical development and sex. It was in agreement with **Sobhy et al.[11]** who after diagnosis with various types with wounds found no significant disparity in results between the two sexes.

There was a statistically negative association between clinical progress and age as progress in younger patients was marginally stronger according to our study that, in agreement with **Lee, [12]** who noticed a substantial difference between pre-pubertal patients (< 15 years) and post-pubertal patients (> 15 years) in Asians, suggested hormonal activity as a possible explanation for this.

However, after treating scars with a fractional CO₂ laser, **Gold [13]** also found no significant difference in clinical outcomes with age.

Eleven patients (55%) had skin color II and the remaining six patients (30%) had skin color III, while only 3 patients (15%) had skin color IV. This was in accordance with **Tannous,[14]** who indicated that patients with fair skin were suitable candidates for fractional resurfacing However **Goel et al.[15]** who verified the suitability of fractional resurfacing for dark skin (skin type IV).

Our findings were consistent with those stated by **El Taweel and Abd El-Rahman,[16]** who demonstrated those 17 patients with 20 scars (68 per cent) were happy to be extremely satisfied. Just two patients were not happy with two wounds (8 per cent).

In this study, there was no statistically significant difference in the clinical change between depressed and slightly elevated scars and this was also found by **Sobhy et al.[11]** as regards side effects, Fractional Photothermolysis seemed to be a fairly safe treatment process. Care was fairly safe medical modalities. In general the diagnosis was well received. Both patients had been diagnosed with post-laser erythema and crusting. Fortunately, no other side effects have been found in our patients, although after fractional laser therapy **Geronemus[17]** reported side effects such as pigment changes, inflammation, and scars.

For this study the disparity for doctors, assessment and patient satisfaction was highly important. This is agreement with **Chua et al.[18]** who indicated that evaluation of the patient and assessment of a doctor may be very similar.

Two burn-scars were used in the current report. The scar presentation has had an overall change. **Waibel and Beer[19]** published a case study on the efficacy of FP for burn wounds with postulated mechanisms of this technology's particular efficacy resulting from higher penetration depth and stimulation of wound healing properties. **Salles et al.[20]** used fractional CO₂ laser in the treatment of burn wounds, and 57 percent of patients reported clinical improvement.

During the procedure, eight per cent of patients had no to mild pain and Fisher and Geronemus also reported the same result[21].

In their study, **Scrimalet al.[22]** showed improvement in the clinical appearance of atrophic and hypertrophic scars with no significant adverse effects on patients when using 10,600 nm wavelength fractional CO₂ technology.

The patients also underwent subjective assessment at the last follow-up visit. Majority of patients were pleased with the care offered with 60 percent rating their response as (highly pleased) while no patients were not satisfied with the results of the care. After diagnosis, only 20 per cent of patients were happy with their results. The writers are the main criterion for the study conducted by **Dierickx et al.[23]** as there is no subjective score to measure the scar progress, and it is just a translation of author knowledge.

A previous research investigated the fractional CO₂ laser for surgical and post-traumatic scar found clinical improvement in scars by 40% of patients had an outstanding improvement of 76-100% (grade 3), 50% of patients had a reasonable improvement of 50-75% (grade 2), 10% had a decent improvement of 26-49% (grade 1) at 3 months fol [24].

Our research is consistent with Gladstone's analysis as it explored the clinical efficacy of fractional laser in the treatment of post burn scars. This has been found to provide highly regulated ablation with minimal thermal necrosis, even after several passages such as post-burn wounds, adnexal structures are typically broken and spontaneous healing can result from the healthy skin around, which can lead to delayed healing of the wound. Laser CO₂ is more effective for smoothing scars [25].

Fractional laser resurfacing has been used with success in treatment of post acne atrophic scars of variable morphology. Similar therapeutic benefit can be expected in post-traumatic and post burn scarring because the process underlying all these etiological types of scars is fundamentally the same. In one of the earliest studies on fractional lasers in burn scars, amateur scar was shown to improve considerably after five monthly sessions with a fractional device. The authors reported improvement in the scar appearance as well as contracture [26].

It has been shown that fractional CO₂ laser is efficient for burning scars even in the dark skin forms. Additionally, no permanent dyschromia has been noted in these clinical studies after the use of fractional CO₂ devices. As the studies have reported histopathological evidence of substantial increases in Type III collagen and decreases in Type I collagen after resurfacing on a burn scar with fractional CO₂ laser [27].

Data from the study conducted by **Vercelli et al.[28]** indicate that resurfacing fractional laser with CO₂ laser is a safe and efficient treatment choice for post-traumatic and post-burn scars. Scars are expected to respond to this modality of treatment with reasonably good to excellent results anywhere in the body.

Non-ablative fractional lasers (NAFL) have fewer side-effects than ablative fractional lasers (AFL); NAFL is a safe and efficient post-traumatic scar treatment tool. However, there is a longer pause and more pain in AFL compared with NAFL during the care of patients. Seen side effects were intermittent and included 2-4 days post-treatment erythema and crusting, and post-inflammatory pigmentation. The latter is seen almost uniformly in darker skin types (Fitzpatrick III-VI) which have been tested for longitudinal scars on the face [29].

While commenting on the therapeutic results achieved with fractional laser resurfacing, it is important to realize that there is a lack of uniform objective assessment of the therapeutic benefit achieved. Majority of the clinical studies on fractional laser technology have used quartile grading systems or patient satisfaction as the criteria to assess the therapeutic results. This makes it important to employ a score that takes into account all of these variables individually to assess any therapeutic benefit it also means that assessing just the volume change in a scar by objective tools is not sufficient to gauge the response to fractional laser resurfacing.

Lastly, it is important to realize that a typical patient has scars of different morphological types and grades and it is difficult to treat all these scar types satisfactorily with a single treatment option and multiple techniques are required. However, of all the treatment options available to treat post-traumatic scars, fractional photothermolysis is probably the only monotherapy that offers the highest degree of scar amelioration and patient satisfaction.

CONCLUSION

Fractional CO₂ lasers are considered an effective and safe modality for treatment of moderate to severe post-traumatic scars especially in younger age patients (15-35 yrs old) with skin type II with no need for down time and patients in this study did not disturb their daily activity. Its side effects are transient, self-limited and with low incidence.

Based on the conclusions that have been reached in this study, we need further studies on the long-term efficacy of NAFL resurfacing. Most studies followed patients for 3-6 months and not follow patients for up to 2 years. Combination of different treatments for post-traumatic scars may

be effective and synergistic challenge for its treatment. No definite numbers of sessions or definite period between treatment sessions were established. We preferred to choose 3-4 weeks interval period to allow collagen remodeling and neocollagenesis. Better results might have been achieved by longer interval. Fractional CO₂ lasers are preferred for young age patients (15-35) with skin type II regardless to their site of the post-traumatic scar. Other post-traumatic scars patients could be treated with other therapeutic modalities like intraregional steroids and chemical pressure therapy.

REFERENCES

- 1-Sherratt JA.** Mathematical modelling of scar tissue formation. Edinburgh, Scotland: Department of Mathematics, Heriot-Watt University.2010; 89: 44-78.
- 2-Keen A, Sheikh G, Hassan I, Jabeen Y, Rather S, Mubashir S, et al.** Treatment of post-burn and post-traumatic atrophic scars with fractional CO₂ laser: experience at a tertiary care centre. *Lasers Med Sci.* 2018; 33:1039-46.
- 3-Alster TS, Tanzi EL, Lazarus M.** The use of fractional laser photothermolysis for the treatment of atrophic scars. *Dermatol Surg.* 2007;33:295-9.
- 4-Ibrahim SM, Elsaie ML, Kamel MI, Mohammed EE.** Successful treatment of traumatic scars with combined nonablative fractional laser and pinpoint technique of standard CO₂ laser. *Dermatol Ther.* 2016; 29(1), 52-7.
- 5-Well D.** Acne vulgaris: A review of causes and treatment options. *Nurse Pract.* 2013; 38(10), 22-31.
- 6-Zaleski-Larsen LA, Fabi SG, McGraw T, Taylor M.** Acne scar treatment: a multimodality approach tailored to scar type. *Dermatol Surg.* 2016; 42, S139-S49.
- 7-Karmisholt KE, Wenande E, Thaysen-Petersen D, Philipsen PA, Paasch U, Haedersdal M.** Early intervention with non-ablative fractional laser to improve cutaneous scarring A randomized controlled trial on the impact of intervention time and fluence levels. *Lasers Surg Med* 2018; 50(1), 28-36.
- 8- You HJ, Kim DW, Yoon ES, Park SH.** Comparison of four different lasers for acne scars: Resurfacing and fractional lasers. *Journal of Plastic, Reconstructive & Aesthetic Surgery,* 2016; 69(4), e87-e95.
- 9- Majid I, Imran S.** Efficacy and safety of fractional CO₂ laser resurfacing in non-hypertrophic traumatic and burn scars. *J Cutan Aesthet Surg.* 2015; 8(3), 159.
- 10- Weiss ET, Chapas A, Brightman L, Hunzeker C, Hale EK, Karen JK, et al.** Successful treatment of atrophic postoperative and traumatic scarring with carbon dioxide ablative fractional resurfacing: quantitative volumetric scar improvement. *Arch Dermatol.* 2010; 146(2), 133-140.
- 11-Sobhy N, El-Shafaei A, Kamal N.** Department of Dermatology & Venereology, Faculty of Medicine, Alexandria University, Egypt *Dermatol Online.* 2012; 3(3): 188-195.
- 12-Lee Y.** Combination treatment of surgical, post traumatic and post- herpetic scars with ablative lasers followed by fractional laser and non ablative lasers in Asians. *Lasers surg Med* 2009; 41:131-140.
- 13-Gold M.** Clinical evaluation of a microablative/fractional carbon dioxide laser for the treatment of photo damage and scars. *J Am Acad Dermatol.* 2010; 62:142.
- 14-Tannous Z.** Fractional resurfacing. *Clinics Dermatol.* 2007; 25(5): 480-6.
- 15-Goel A, Krupashankar DS, Aurangabadkar S, Nischal KC, Omprakash HM, Mysore V.** Fractional lasers in dermatology-Current status and recommendations. *Indian J Dermatol Venereol Leprol.* 2011; 77(3), 369.
- 16- El Taweel AA, Abd El-Rahman SH.** Assessment of fractional CO₂ laser in stable scars. *Egypt J Dermatol Venerol,* 2014; 34(1), 74-80.
- 17-Geronemus RG.** Fractional photothermolysis: current and future applications. *Lasers Surg Med.* 2006; 38:169 -176.
- 18-Chua SH, Ang P, Khoo LS, Goh CL.** Non ablative 1450-nm diode laser in the treatment of facial atrophic acne scars in type 4 to 5 Asian skin: a prospective clinical study. *Dermatol Surg.* 2004; 30: 1287-91.
- 19-Waibel J, Beer K.** Ablative fractional laser resurfacing for the treatment of a third degree burn. *J Drugs Dermatol.* 2009; 8:294-297.
- 20- Salles A, Remigio A, Zacchi V, Ferreira M.** Treatment of facial burn sequelae using fractional CO₂ lasers in patients with skin phototypes 3 to 4. *Rev Bras Cir.* 2012; 27(1), 9-13.
- 21- Fisher GH, Geronemus RG.** Short-term side effects of fractional photo thermolysis. *Dermatol Surg.* 2015; 31: 1245 -9.
- 22- Scrimali L, Lomeo G, Nolfo C, Pompili G, Tamburino S, Catalani A, et al.** Treatment of hypertrophic scars and keloids with a fractional CO₂ laser: a personal experience. *J Cosmet Laser Ther.* 2010; 12(5), 218-21.
- 23-Dierickx C, Khatri K, Altshuler G, Erofeev A, Smirnov M, Tabatadze D, et al.**

Fractionated delivery of Er: YAG laser light to improve efficacy and safety of ablative resurfacing procedure. *Lasers Surg Med.* 2007; S19.

- 24- Waibel J, Graber E, Davis S, Badiavas E.** Effects of erbium fractional resurfacing on third degree hypertrophic burn scars. *Lasers Surg Med.* 2012; 44, 11-11.
- 25-Thomas JR , Somenek M.** Scar revision review. *Facial Plast Surg.* 2012;14:162-174.
- 26-Haedersdal M.** Fractional ablative CO₂ laser resurfacing improves a thermal burn scar. *J Eur Acad Dermatol Venereol.* 2009; 23(11), 1340-1.

27- ChoSB, Lee SJ, Chung WS, Kang JM, Kim YK. Treatment of burn scar using a carbon dioxide fractional laser. *J Drugs Dermatol.* 2010; 9(2), 173-5.

28-Vercelli S, Ferriero G, Sartorio F, Stissi V, Franchignoni F. How to assess postsurgical scars: a review of outcome measures. *Disability and rehabilitation,* 2009; 25(31), 2055-63.

29- Vasily DB, Cerino ME, Ziselman EM, Zeina ST. Non-ablative fractional resurfacing of surgical and post-traumatic scars. *J Drugs Dermatol.* 2009; 8(11), 998-1005.

How to cite

Mohamed, M., Abdel-Mowla, M., Khater, E. Fractional CO₂ Laser in Treating Post Traumatic Scars. *Zagazig University Medical Journal,* 2022; (207-216): -. doi: 10.21608/zumj.2020.26238.1777