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Evaluation of safety and efficacy of fractional CO_2 laser in treatment of post traumatic atrophic scars

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Abstract
Aim: This research evaluated the safety and efficacy of fractional CO_2 LASER (FCOL) in treatment of post traumatic atrophic scarring.
Research design: This was a prospective, randomized research.
Place and duration of the research: Outpatient Dermatology and Venereology Clinic and Plastic Surgery Departments at Tanta University Hospitals, from December 2019 to June 2021.
Methodology: This research was carried out on 20 participants with post traumatic atrophic scarring treated with FCOL. Follow up 3 months after treatment and evaluation of the improvement was done by Vancouver scar scale, 3 blinded dermatologists' assessment, and patient satisfaction score.
Results: There was improvement in all participants with variable degrees, there were no scarring showed excellent improvement, 4 scarring showed good improvement (20%), 10 scarring showed fair improvement (50%) and 6 scarring showed poor improvement (30%). Adverse reactions were in general mild and well tolerated, in the form of transient redness, mild hyperpigmentation, mild pain, that all resolved within few days. No relation between the degree of improvement and age of the participants, site of the scarring, scar duration, but in sex of the participants, it was more in males than in females.
Conclusion: FCOL may be an effective approach for treating atrophic scarring, from both an aesthetic and a functional perspective.

Keywords: Atrophic scarring**,** fractional CO_2 laser

Introduction
Atrophic scarring, also known as dermal depressions with underlying thinning epidermis, form when dermal collagen is lost due to inflammation or trauma. This may occur after conditions like acne, varicella, post-traumatic wounds, or surgical scarring [1]. Scarring may seem like a purely aesthetic issue at first, but it may have serious implications for the patient's health and well-being on many other levels as well. Scarring may physically limit the patient's movements and cause discomfort, numbness, and itching [2]. Cosmetic improvements to atrophic scarring have been the focus of several treatment options, including but not limited to chemical peeling [3], subcision [4], dermabrasion [5], fillers [6], platelet rich plasma and microneedling [7]. Despite ablative lasers' major therapeutic benefits, adverse reactions such delayed post-procedure erythema and dyspigmentation prevent them from being widely used, particularly on participants with darker skin [8]. Non-ablative lasers, such as diode, neodymium-doped yttrium aluminium garnet (Nd-YAG), and pulsed dye laser (PDL), offer higher safety profiles but lower efficacies [9]. FCOL resurfacing has been shown to be effective in treating many different skin conditions in a number of randomised, controlled clinical studies such as photoaged skin and rhytides [10], atrophic acne scarring [11] as well as postoperative and traumatic atrophic scarring [12].

Material and Methods
Research design: This was a prospective, randomized research.
This research was carried out on 20 participants with post traumatic atrophic scarring fulfilled all the ethical aspects required in human research of ethical committee of Faculty of Medicine Tanta University with approval code 33465/11/19. The participants were recruited from the outpatient Dermatology and Venereology Clinic and Plastic Surgery Departments at

Tanta University Hospitals, from December 2019 to June 2021.

Inclusion criteria

Newly diagnosed cases of post traumatic atrophic scarring with duration more than six months. And have an atrophic scar from a previous injury at any site without recent treatment within the previous six months before enrollment in this research. Participants who completed an informed consent form and remained in the research to the end of the follow-up period.

Exclusion criteria

Participants with blood disease (hemophilia, coagulopathy), participants with systemic disease as renal diseases, hepatic diseases, diabetes mellitus or any disease affecting healing, pregnancy, participants on current anticoagulative medication, participants with history of malignancy or radiation therapy, participants with photosensitivity, participants with infections or viral skin diseases, participants with history of keloid tendency, participants with immunosuppression, long-term systemic corticosteroid therapy, individuals with scarring who have had therapy in the last six months, as well as participants who have been using either systemic retinoids or topical retinoids during the previous six months or two weeks, are eligible to participate in this research.

Method

All participants were given the same standard protocol, which included information on the procedure, its risks, and any potential benefits. Participants provided their written informed permission. All participants in this trial had a comprehensive history taken using a standardized form that included questions about their demographics (such as name, age, gender, ZIP code, employment, marital status, and dietary preferences) and medical conditions, present history, onset, duration, course, history of precipitating and aggravating factors, medical history of systemic disease, skin healing disorders and history of previous scarring treatments as chemical peeling or dermabrasion.

General examination: To exclude systemic diseases.

Full examination of the scar according to Vancouver scar scale (VSS) [13] regarding erythema, pigmentation, pliability (Height wasn't detected) Table (1).

Photographic documentation was done with 16.2 mega pixels digital camera (Sony cyber shot DSC-TX10, Japan).

Therapeutic regimen

Fractional CO_2 laser (FCOL) sessions

Pretreatment preparation: Participants applied a 5% lidocaine cream to the scar 30 minutes before laser sessions. The scar was then disinfected and degreased with antiseptic solution. Protective goggles were applied for patient, doctor, and assistant.

Procedure: All participants recieved 3 sessions of fractional ablative CO_2 laser (10,600 nm) with one month apart. The FCOL used is (SmartXide Dot ®-DEKA.Italy*)*. During the procedure, a smoke ejector was deployed. The participants treated with fractional ablative CO_2 laser at a setting of power range from 13 to 15 watts, smart stack 1, spacing 500µm**,** dwell time 800- 1000 µs. The participants were advised to use sunscreen and avoid rubbing, scratching, or peeling the skin too soon.

Evaluation of the efficacy of the therapeutic procedures:

Clinical evaluation: The atrophic scarring were assessed according to the VSS for vascularity, pigmentation, pliability, and the score was compared before and 3 months after the end of the treatment. Physician opinion, comparison of photos before and after treatment by 3 blinded dermatologists. The degree of improvement was evaluated using a quartile grading scale as following [14]:

75%-100% = excellent improvement.
50%-75% = good improvement.
25%-50% = fair improvement.
(0-25%) = poor improvement.

Patient's satisfaction

At their last appointment, participants were asked to assess their overall satisfaction relative to where they were before therapy [15]:

Grade 1: Not satisfied.
Grade 2: Slightly satisfied.
Grade 3: Satisfied.
Grade 4: Very satisfied.

Participants were informed to report any allergy symptoms, as well as erythema, discomfort, ecchymosis, infections, post-inflammatory hyperpigmentation, and other signs of hypersensitivity. Negative consequences include any clinical medical occurrence, whether noticed by the researcher or reported by the patient.

Follow up assessment: Three months following the last session, participants were tracked and examined clinically by colored photography to identify any improvement or worsening of the scarring and to detect any problems.

Statistical analysis of the data

Information was entered into the computer and analysed using IBM's SPSS software programme, version 20.0. IBM Corporation, Armonk, New York**.** Quantitative and percentage descriptions were used to describe qualitative data. In order to ensure that the data were normally distributed, the Kolmogorov-Smirnov test was performed. The lowest and maximum values, as well as the mean, standard deviation, median, and interquartile range, were used to characterize the numerical data (IQR). Results were considered significant at the 5 percent level.

Results

Regarding demographic data: sex and age: 16 males (80%), their age ranged from 13 – 32 years with a mean ± SD of 20.10 ± 0.36. Scar duration: the duration of scarring ranged from 1.50 -10 years with a mean± SD of 5.05 ± 2.87. Fitzpatrick skin type: there were 8 participants (40%) with skin type III and 16 participants (60%) with Fitzpatrick skin type IV.

Scar site: there were 6 participants (30%) with facial scarring, 10 participants (50%) with scar on upper limb and 4 participants (20%) on lower limb. Table (1)

Table 1: Statistical distribution of the sex, age, duration, Fitzpatrick skin type and scar site.

Sex			Scar Site			Skin type			Scar Duration (years)		Age (years)	
	No.	%		No.	%		No.	%	Min.-Max.	1.50-10.0	Min.-Max.	13.0-32.0
Male	16	80	Face	6	30	III	8	40				
			Upper limb	10	50				Mean ± SD.	5.05 ± 2.87	Mean ± SD.	20.10 ± 6.30
Female	4	20	Lower limb	4	20	IV	12	60	Median (IQR)	5.0 (3.0 – 7.0)	Median (IQR)	18.50(15.0 – 25.0)

IQR: Inter quartile range
SD: Standard deviation

All participants showed progressive and clinical improvement, there were no scarring showed excellent improvement, 4 scarring showed good improvement (20%), 10 scarring showed fair improvement (50%) and 6 scarring showed poor improvement (30%). Figure (1, 2).

Regarding to adverse reactions: there were 6 participants reported pain (30%), 6 participants reported erythema (30%), 6 participants reported pigmentation (30%), there was no patient reported oedema and bruising.

Patient satisfaction: there was no very satisfied participants, 6 satisfied participants (30%), 6 slightly satisfied (30%) and 8 not satisfied (40%). Table (2).

Table 2: Distribution of the participants according to clinical degree of improvement, patient satisfaction score and adverse reactions.

Clinical degree of improvement	(n = 20)		Patient satisfaction	(No = 20)		Side effect	(No = 20)	
	No.	%		No.	%		No.	%
Excellent	0	0	Very satisfied	0	0	Pain	6	30
Good	4	20						
Fair	10	50	Satisfied	6	30	Erythema	6	30
Poor	6	30						
Min.-Max.	10.0-70.0		Slightly satisfied	6	30	Pigmentation	6	30
Mean ± SD.	38.0 ± 18.29					Oedema	0	0
Median (IQR)	37.50(25.0-50.0)		Not satisfied	8	40	Bruising	0	0

IQR: Inter quartile range
SD: Standard deviation

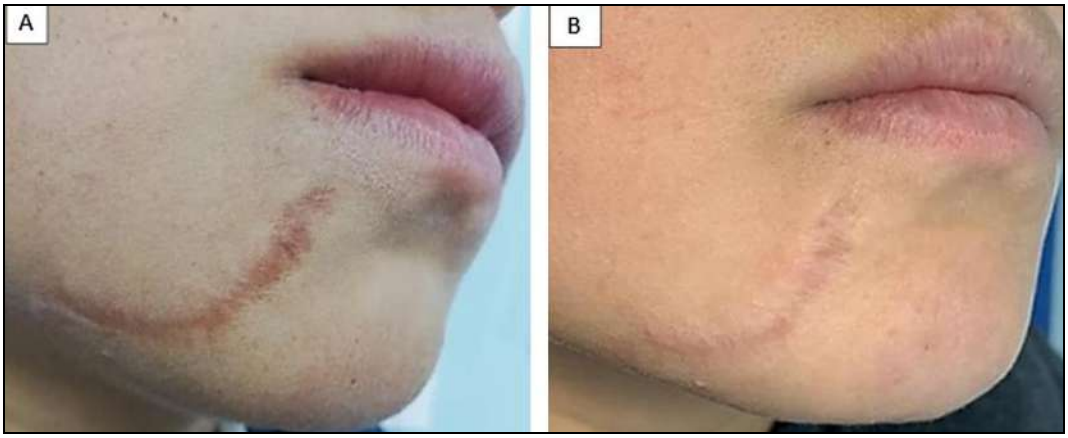

Fig 1: Male patient 14 years old with post traumatic atrophic scar of 6 years duration in the right mandibular area. (A) before treatment. (B) three months after treatment, showed good improvement.

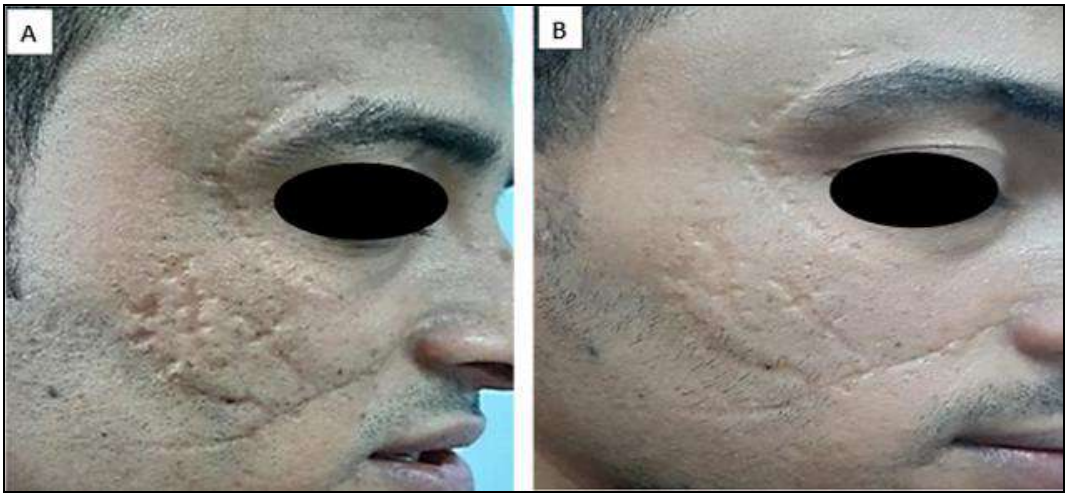

Fig 2: Male patient 32 years old with post traumatic scar of 4 years duration in the right zygomatic. (A) Before treatment. (B) 3 months after treatment, showed good improvement.

Regarding scar erythema: before treatment, there were 8 normal color scarring (40%), 6 pink scarring (30%) and 6 red scarring (30%). After treatment there were 12 normal color scarring (60%), 2 pink scarring (10%) and 6 red scarring (30%), there was a statistically insignificant difference between before and after treatment p (0.157). Table (4).

Regarding scar pliability, before treatment, there were 6 normal scarring (30%), 6 supple scarring (30%), 4 yielding scarring (20%) and 4 firm scarring (20%). After treatment, there were 12 normal scarring (60%), 4 supple scarring (20%), 4 yielding scarring (20%) and no firm scar, the uniformity of scarring was significantly different between the pre- and post-treatment periods P (0.008).

Regarding scar pigmentation, before treatment, there were 6 normal scarring (30%), 6 hypopigmented scarring (30%) and 8 hyperpigmented scarring (40%). After treatment, there were 12 normal scarring (60%), 6 hypopigmented scarring (30%) and 2 hyperpigmented scarring (10%), there was a statistically insignificant difference between before and after treatment p (0.083). Table (3)

Table 3: Comparison of scar erythema, pigmentation, pliability between before and after treatment.

Erythema (vascularity)	(No = 20)		Pliability	(No= 20)		Pigmentation	(No = 20)	
	No.	%		No.	%		No.	%
Before			**Before**			**Before**		
Normal	8	40	Normal	6	30	Normal	6	30
			Supple	6	30			
Pink	6	30	Yielding	4	20	Hypopigmentation	6	30
Red	6	30	Firm	4	20	Hyperpigmentation	8	40
After			After			After		
Normal	12	60	Normal	12	60	Normal	12	60
Pink	2	10	Supple	4	20	Hypopigmentation	6	30
Red	6	30	Yielding	4	20	Hyperpigmentation	2	10
			Firm	0	0			
MH (p_0)	1.000 (0.157)		MH (p)	9.500* (0.008*)		MH (p)	3.000 (0.083)	

MH: Marginal Homogeneity Test

p_0: p value for comparing between before and after treatment.

*: Statistically significant at $p \leq 0.05$

There is no relation between the degree of improvement and age of the participants, site of the scarring, scar duration but according to participants' sex, the improvement was more in males than in females.

Table 5: Correlation between degree of improvement and different parameters

		No	Degree of improvement			Test of Sig.	P
			Min.-Max.	Mean ± SD.	Median		
Sex	Male	16	25.0 – 70.0	43.75 ± 15.29	40	U=	0.044*
	Female	4	10.0 – 20.0	15.0 ± 7.07	15	0.0*	
Site	Face	6	10.0 – 70.0	43.33 ± 30.55	50	H=	0.64
	Upper limb	10	20.0 – 60.0	34.0 ± 15.57	30	0.893	
	Lower limb	4	40.0 – 40.0	40.0 ± 0.0	40		
Age (years)		Degree of improvement					
		Rs			P		
	(No = 20)	-0.347			0.327		
Scar duration (years)	(No = 20)	-0.207			0.566		

U: Mann Whitney test

H: H for Kruskal Wallis test

p: p value for comparing between clinical improvement and different parameters

r_s: Spearman coefficient

*: Statistically significant at $p \leq 0.05$

Discussion

Scarring form when the skin's natural wound-healing mechanisms are disrupted. Deformities in function and appearance, discomfort, itching, pain, psychological stress, and patient discontent are some of the most prevalent and annoying difficulties following injury. The range of motion in affected joints may be diminished, along with functional ability and quality of life [16]. Atrophic scarring are dermal depressions that generally occur because of collagen destruction during post traumatic healing and an inflammatory skin disease such as cystic acne or varicella [17]. Many different treatment modalities, both non-invasive and invasive, are used to improve scarring. Laser-based scar resurfacing is currently considered to be one of the most effective treatment options for all types of scarring. Although ablative lasers like the CO_2 and Er: YAG used in skin resurfacing may be effective in treatment of various scarring, their widespread use is limited by serious adverse reactions [18]. FCOL provide many benefits over traditional surgery, including less tissue damage, edema, and recovery time. The significant concern, however, was the observed thermal stress to the adjacent tissue [19].

The aim of our research was evaluation of safety and efficacy of fractional CO_2 in treatment of post-traumatic atrophic scarring. This research was carried out on 20 participants with post traumatic atrophic scarring which, treated with 3 sessions of FCOL with one month interval.

The research included 16 males (80%) and 4 females (20%).

Their age ranged from 13 – 32 years with a mean ± SD of 20.10 ± 0.36. The duration of scarring ranged from 1.50 -10 years with a mean± SD of 5.05 ± 2.87.
Fitzpatrick skin type: there were 8 participants (40%) with skin type III and 12 participants (60%) with Fitzpatrick skin type IV.
At the end of the research, the efficacy of treatment was evaluated by VSS (scar erythema, pigmentation and pliability), physician opinion, patient's satisfaction score, adverse reactions, safety and follow up assessment.
Regarding degree of improvement, there were no scarring showed excellent improvement, 20% scarring showed good improvement and 50% scarring showed fair improvement and 30% scarring showed poor improvement, there was a statistically insignificant difference between before and after treatment regarding scar erythema and pigmentation, but there was a statistically significant difference in scar pliability between before and after treatment P (0.008). Regarding patient satisfaction, only 30% were satisfied and there is no relation between the degree of improvement and age of the participants, site of the scarring, scar duration but according to participants' sex, the improvement was more in males than in females as the number of males was more than females because young males are more susceptible to trauma than females.
Majid and Imran [20] examined the effects of four FCOL resurfacing treatments, spaced six weeks apart, on 25 participants with atrophic and normotrophic traumatic and burn scarring. Sixty percent of their participants were deemed to have an excellent response to treatment, with the remaining 24 percent and 16 percent being classified as good and poor responders, respectively. Only 16% of people showed a noticeable change in their scarring. Nineteen of the twenty-five participants reported very high levels of satisfaction. Their results showed more improvement compared to our results may be due to more number of sessions, longer follow up, different participants' races and skin types. Keen *et al*. [1] also evaluated the FCOL in the treatment of post-burn and post-traumatic atrophic scarring. They carried out their research on 100 participants; they were treated with monthly sessions of FCOL treatment for 6 months. Even after a year without further therapy, the patient's condition had improved to perfection. Treatment response ranged from "excellent" (53.75%) to "good" (16.25%) to "poor" (30%). Their results showed better improvement compared to our results that may be due to more treatment sessions per scar (6 sessions versus 3 in our research) and a longer period of follow up.
In agreement with Rasheed *et al*. [21], who evaluated 20 male participants, with linear atrophic post-traumatic facial scarring and classified into two groups, to determine the effectiveness and safety of fractional CO_2 in treating these scarring with different parameters between the two treated groups. Their participants received three treatments sessions, each spaced out by four weeks. After two months follow-up, the results can be described as fair to good with an overall average percent of improvement of 42.85% in group I and of 35.29% in group II.

Conclusion

Fractional CO_2 laser is effective in treatment of post traumatic atrophic scarring, the improvement achieved after treatment not only was maintained throughout the whole period of follow-up but also the improvement was still going on after treatment. However, the obvious improvement appeared within 3 months after treatment. Our recommendation is to increase number of fractional CO_2 sessions to achieve the required improvement.

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Contributions of Authors: All authors have made major contributions to the research's idea, implementation, and analysis. They have evaluated the entire paper and confirmed its veracity.

The authors did not accept compensation for this research.

Consenting

Before their participation, informed permission was acquired from all participants. Every patient was assigned a code number, ensuring his confidentiality.

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