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ORIGINAL ARTICLE

Treatment of Atrophic Facial Acne Scars on the Face with Ablative Non-Fractional Erbium: YAG laser (2940 nm)

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ABSTRACT

Background: *Acne scarring is a common dermatologic problem causing a great cosmetic disfigurement. There are several available treatment modalities, however, there is no method that can be considered the optimal satisfactory one for all patients.*

Objective*: To assess the safety and effectiveness of ablative leaser therapy (Non-Fractional Erbium YAG Laser (2940 nm) as an option in the treatment of Iraqi patients with atrophic acne scars in the face.*

Patients and Methods: *This study included a total of 19 patients of both genders who underwent two sessions of non-fractional Erbium: YAG laser (2940 nm) were applied at one month interval. The patients were assessed before treatment and received two sessions with one month interval and followed up for three months after the last sessions. We objectively evaluated the effectiveness of treatment according to Goodman and Baron's acne scar grading system as well as the photographic assessment. Additionally, patient's satisfaction was determined.*

Results: *The mean Goodman and Baron's score before treatment was 3.64±0.49 and significantly decreased to 2.58±0.71 at the end of follow up period (P. value <0.001). According to the photographic assessment, 11 patients (64.7%) had fair improvement, 6 patients (35.3%) had good improvement and no patient had poor or excellent improvement. Five patients (29.41%) were mildly satisfied and 12 patients (70.59%) were moderately satisfied. All patients had mild post operative burning pain last for several hours to 2 days and erythema last for 1-2 weeks. Only one patient (6%) developed mild post inflammatory hyperpigmentation. No significant complications had been recorded.*

Conclusions: *Erbium: YAG laser (2940 nm) is an effective and safe method for treatment of atrophic facial acne scars in Iraqi patients.*

Keywords: *Acne, Scars, Atrophic, Facial, Laser, ablative. Erbium: YAG laser*

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1. INTRODUCTION

Acne scarring is a consequence of abnormal resolution or wound healing following the damage that occurs in the sebaceous follicle during acne inflammation [1]. Acne scars can exist in many forms, such as superficial macular scars, ice pick scars (cone-shaped), rolling scars (wavy), boxcar scars (chicken pox scar like), hypertrophic scars and keloids [2,3]. Scarring usually follows deep inflammatory lesions, but may often happen after superficial lesions in scar – prone patients . Treatment of acne scarring is much more tedious and ineffective than its prevention [4,5]. Therapeutic approaches for atrophic scars include several methods and therapeutic modalities. Various techniques are available for treatment of atrophic post-acne scars, and they are categorized into energy-based and non-energy-based. Energy-based technologies include ablative and non-ablative laser skin treatments, fractional radiofrequency irradiation, and phototherapy. Non-energy-based methods include subcision, microdermabrasion, microneedling, dermal fillers, and chemical peels. Also, Platelet-rich plasma (PRP) therapy, injection of autologous fibroblast culture, mesotherapy, cryotherapy, physiotherapeutic methods; drug phoresis, ultrasound therapy are used in treatment of atrophic post-acne scars [6]. Chemical peels involve applying chemical agents to the skin at varying penetration depths to initiate traumatic exfoliation, stimulating remodeling processes in the dermis with a gradual smoothing of the skin's surface [7]. Subcision is an invasive procedure involving percutaneous needle insertion under the scar defect to separate the fibrous bands of the scar from the underlying tissue and create a traumatic channel, which is subsequently filled with connective tissue, thickening the scar base and reducing the degree of depression [8]. Dermabrasion and microdermabrasion are mechanical abrasion techniques for removing layers of skin with subsequent re-epithelialization. This method has limited applicability due to its traumatic nature and the high risk of developing pathological scars and dyschromia [9]. Microneedling involves multiple superficial perforations of the skin by rolling a dermaroller and is used to address dyschromia, age-related skin changes, and atrophic post-acne scars [10].

Autologous fat augmentation (lipofilling) is highly biocompatible, but this method requires specialized skills and involves an invasive procedure of fat harvesting in the operating room, preparation of the sample, and its subsequent injection into the area of scar deformity [11,12] Platelet-rich plasma (PRP) used as biological therapy to correct atrophic post-acne scars [13].

Laser technologies: Many Researchers noted that laser technologies are among the most effective methods for correcting atrophic post-acne scars on the face [14–17], on the other hand some authors focused on the clinical efficacy of ablative laser techniques compared to non-ablative ones[18–20].

Therefore, the professional community remains interested in studying the effectiveness of these techniques in the treatment of atrophic post-acne scars [21,22]

Non-ablative and ablative lasers are used in continuous spot or fractional mode. The biological effect of high-intensity laser therapy on tissue is achieved through ablation and coagulation of the skin, leading to re-epithelialization and remodeling of dermal structures, resulting in reduced scar depth, a low risk of side effects, and a shorter recovery period [18,19].

Fractional erbium laser is an effective and minimally invasive technology. The advantage of using an erbium laser compared to a CO 2 laser is greater efficiency in terms of color, texture, and relief of post-acne scars, shorter rehabilitation periods, and a reduced risk of adverse events. Epithelialization of the surface treated with an Er: YAG (2940 nm) laser occurs in an average of 5.5 days compared to 8.5 days when using a CO 2 laser; post-inflammatory erythema subsides within 3–4 weeks; the risk of pigmentation is significantly reduced [14,23–25]. Non-ablative lasers are capable of creating intradermal thermal damage zones without damaging the integrity of the epidermis; this phenomenon of fractional photothermolysis limits the risk of side effects and reduces recovery time [25,26]

Fractional radiofrequency irradiation for the treatment of atrophic acne scars is a new technology. Researchers noted its effectiveness as being similar to laser technologies [6,16,27]

The side effects and complications of ablative laser skin resurfacing are diverse and significantly affected by the postoperative care, selected patient, as well as the proficiency of the medical professionals. However, the rates of experiences side effects of Er: YAG laser skin resurfacing are generally close to that of CO2 Laser, but when occurred, they are less severe and transient in comparison to those with CO2[28]

2. METHODOLOGY

This was a prospective study conducted during 12 months at the University of Kufa, Laser-Research Unit of the Medical College and included a total of 19 Iraqi patients of both genders who were presented with bilateral depressed facial acne scars and scheduled for treatment with Er: YAG 2940 nm laser therapy. The specifications of the Er: YAG 2940 nm laser device used in the study are listed below

- Wavelength: 2940 nm
- Pulse width: 0.3 ms
- Fluence: 6 J/cm2
- Spot size: 3.5 mm
- Frequency: 5 Hz
- Electrical requirement: 220-230V,16A,50-60HZ

The studied group consisted of 11 males and 8 females aged between 19-45 years, patient was excluded if he/or she got a previous treatment with isotretinoin during the prior 6 months or dermabrasion within the previous 12 months. Pregnant and lactating women were also excluded from the study and were treated with other treatment modalities accordingly.

Furthermore, patients with active lesions of acne, active herpes simplex infection and those with high risk that predisposing them the development of keloid were also excluded.

Data were collected through a full history taking and a thorough clinical examination. The collected data included the demographic data (age, age at onset, gender) as well as the family, medical, and medications history.

On examination, site, type and severity of the lesions were identified and reported. All patients were informed about the treatment procedures, possible side effects, the required photographs before and after treatment and were instructed about the scheduled follow-up time.

The number of treatment sessions were two with a one-month interval. Follow up period continued until three months after the last treatment session.

Preoperatively, a prophylactic antiviral (acyclovir tablet 400 mg) was given orally twice daily 24 hours before each treatment session and continued for 7 days. Thirty minutes before

initiating the treatment method, a topical (EMLA cream) was administered to the affected area as a topical anesthetic agent

Intraoperatively, each patient treated with non-fractional Er: YAG 2940 nm laser, using a pulse width of 0.3 ms, fluence of 6 J/cm², spot size of 3.5 mm and a frequency of 5 Hz.

Three passes of overlapping pulses were delivered and scanning the affected region from various orientations (horizontal, vertical, and oblique) were achieved during each session.

Following the first and second passes, the desiccated whitish skin was removed with saline-soaked gauze following, but retained after the third pass as a protective barrier. Furthermore, at the periphery of the treated region, an additional pass was performed to ensure natural blending and reduce demarcation with the adjacent untreated skin. Patient's eyes were protected by a safety protective goggle

Postoperatively, all patients were instructed to be a way from the exposure to sun for one week postoperatively as well as using the sunscreen topical agents on the exposed lesions. On the other hand, a topical combined hydrocortisone (1% concentration) + Fucidic acid ointments was prescribed to each patient and instructed to use it three times daily for seven days. Cefadroxil capsule 500mg twice daily orally for ten days also was given.

All cases who received the treatment were assessed both objectively and subjectively with regard to their response to treatment.

Objectively, we used the Goodman and Baron's acne scar grading system for evaluation. The degree of scaring was evaluated according to this grading system before treatment and 3 months after the last treatment session. During the postoperative period until the end of the third month after last session, we examine the patients and the lesions were assessed according to the Goodman and Baron's acne scar grading system (Table 1), [29]

Photographic assessment was achieved by two colored photographs were taken by Sony digital, high sensitivity, zoom x20, DSC HX1 Full HD 1080 camera, 9.1 mega pixels camera to every site, the first colored photograph was taken just prior the first session, while at three months after the last session, we took the second photograph. The views that were taken were frontal, right, and left views in the same place with fixed illumination and distance.

Table 1. Qualitative global grading system assessing post-acne scars (Goodman and Brons system) [29]

Grade	Level of disease	Clinical manifestations
1	**Macular**	Erythematous, hyper- or hypopigmented flat scars that do not change the relief of the skin, but affect its color
2	**Mild**	Mild atrophic or hypertrophic scars, not visible at a distance of 50 cm or more, easily cover ed with cosmetic makeup, or by the shadow of hair growing back after shaving the beard hair in men or normal growing hair when extrafacial.
3	**Moderate**	Moderate atrophic or hypertrophic scars, clearly visible at a distance of 50 cm or more, poorly masked by makeup, or the shadow of hair growing after shaving the beard hair in men or normal growing hair when extrafacial. The atrophic scars can be flattened on manual skin stretching.
4	**Severe**	Pronounced atrophic and hypertrophic scars, clearly visible at a distance of more than 50 cm, poorly masked by makeup or the shadow of hair growing after shaving the beard hair in men or normal growing hair when extrafacial. The atrophic scars cannot be flattened on manual skin stretching.

The outcome of treatment was evaluated according to the degree of improvement which was categorized into four quarters and scored from one to 4 where the score of one represents <25% improvement, 25-50% fairly improved, 51-75% as good and >75% as an excellent improvement .

The subjective evaluation depends on the satisfaction of the patients toward the treatment and improvement in the scaring, the satisfaction categorized according to satisfaction score from (0-3), where the grade of 0 represent no satisfaction and the grades (1, 2 and 3) as mild, moderate and fully (complete) satisfaction, respectively,

Follow Up:

On monthly interval, the patients were assessed regarding the improvement of lesions and any possible complications. Follow up period after the last treatment session was three months.

Data management and analysis

The data analysis plan based on the statistical package for social sciences (SPSS), version 26. The qualitative variables were expressed as count (frequency) and simple percentages and compared with chi square test while scale (quantitative) variables presented as mean, standard deviation and compared with paired t test. P value ≤ 0.05 was considered significant.

3. RESULTS

Nineteen patients were included in the study. All patients had bilateral atrophic acne scars of the face. Two patients were defaulted after the first treatment session for unknown reasons. Their ages ranged from 19-45 year with a mean of 26.5±5.9. Age and gender distribution is shown in (**Table 2**).

The improvement in the condition of the patients after treatment sessions was evaluated as followed:

A-Objective methods:

1. Goodman and Baron's acne scar grading system:

According to this system, 11 patients (64.7%) were graded as severe (grade 4) and 6 patients (35.3%) were graded as moderate (grade 3) at the baseline assessment. The mean score value before treatment was 3.64 ± 0.49, while at the end of follow up period it was 2.58 ± 0.71, with statistically significant difference (P-value <0.001) (**Figure 1**).

At the end of follow up period, all patients with moderate (grade 3) disease were improved to mild (grade 2) disease. Regarding patients with severe (grade 4) disease, 6 patients (54.5%) of them were improved to moderate (grade 3), 3 patients (27.3%) of them were improved to mild (grade 2) (figures 5,6,7) and no grade changes had been occurred in 2 patients (18.2%).

2-Photographic assessment:

According to this method 11 patients (64.7%) had fair (grade 2) improvement, 6 patients (35.3%) had good (grade 3) improvement and no patient had poor

(grade 1) or excellent (grade 4) improvements. No significant association was found between age of patients and degree of improvement (P value 0.489). When the degree of improvement compared across both genders, no significant association was found, (P. value>0.05), as shown in (**Table 3**).

B-Subjective methods:

According to this method 5 patients (29.41%) were mildly satisfied (grade 1) and 12 patients (70.59%) were moderately satisfied (grade 2) at the end of follow up period. Neither age nor the gender showed a significant association with the patient's satisfaction at the end of follow up, (P. value>0.05), (**Table 4**).

There is a significant association between patient satisfaction and degree of improvement where all patients with good improvement had moderate satisfaction (P value 0.049) (**Table 5**)

Side effects:

All patients had mild post operative burning pain last for several hours to 2 days and erythema last for 1-2 weeks. Only one patient (6%) developed mild post inflammatory hyperpigmentation after the last session which was significantly improved after one month after treatment with combination of hydrocortisone 1%, tretinoin 0.025% and hydroquinone 2% creams once daily. No other significant side effects had been recorded.

Table 2. Age and gender distribution of the studied group

Age (year)	Male		Female		Total	
	No.	%	No.	%	No.	%
≤ 25	4	44.4	2	25.0	6	35.3
26-30	3	33.3	6	75.0	9	52.9
>30	2	22.2	0	0.0	2	11.8
Total	9	52.9	8	47.1	17	100.0
P. value = 0.164, not significant						

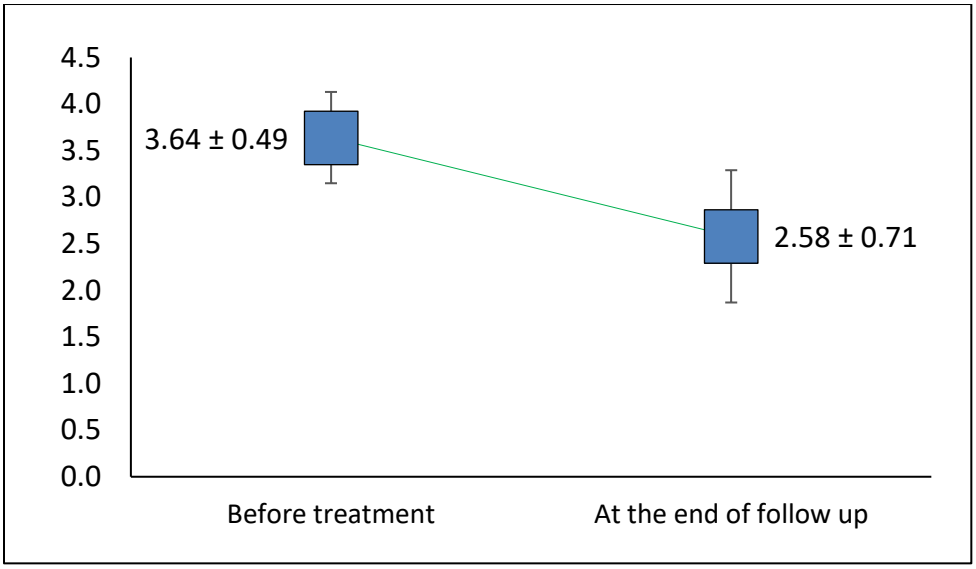


Figure 1. Line-Marker plot showing the change in mean Goodman-Baron's score before and after treatment (P. value <0.001)

Table 3. Association between degree of improvement after treatment and patient's age and gender

Variable	Degree of improvement*				P. value
	Fair		Good		
Age (year)	No.	%	No.	%	
≤ 25	5	45.5	1	16.7	0.489
26-30	5	45.5	4	66.7	
>30	1	9.1	1	16.7	
Gender					
Male	6	54.5	3	50.0	0.858
Female	5	45.5	3	50.0	
Total	11	64.7	6	35.3	

*None of the patients had poor or excellent improvement

Table 4. Association of patient's satisfaction with age and gender

Variable	Patient satisfaction				P. value
	Mild		Moderate		
Age (year)	No.	%	No.	%	
≤ 25	2	40.0	4	33.3	0.713
26-30	2	40.0	7	58.3	
>30	1	20.0	1	8.3	
Gender					
Male	2	40.0	7	58.3	0.49
Female	3	60.0	5	41.7	
Total	5	29.4	12	70.6	

Table 5. Association between photographic assessment and patient satisfaction.

Patient satisfaction	Degree of improvement				Total	
	Fair		Good			
	No.	%	No.	%	No.	%
Mild	5	45.5	0	0.0	5	29.41
Moderate	6	54.5	6	100.0	12	70.59
Total	**11**	**100.0**	**6**	**100.0**	**17**	**100.0**

P. value = 0.049 significant

Clinical examples from our study

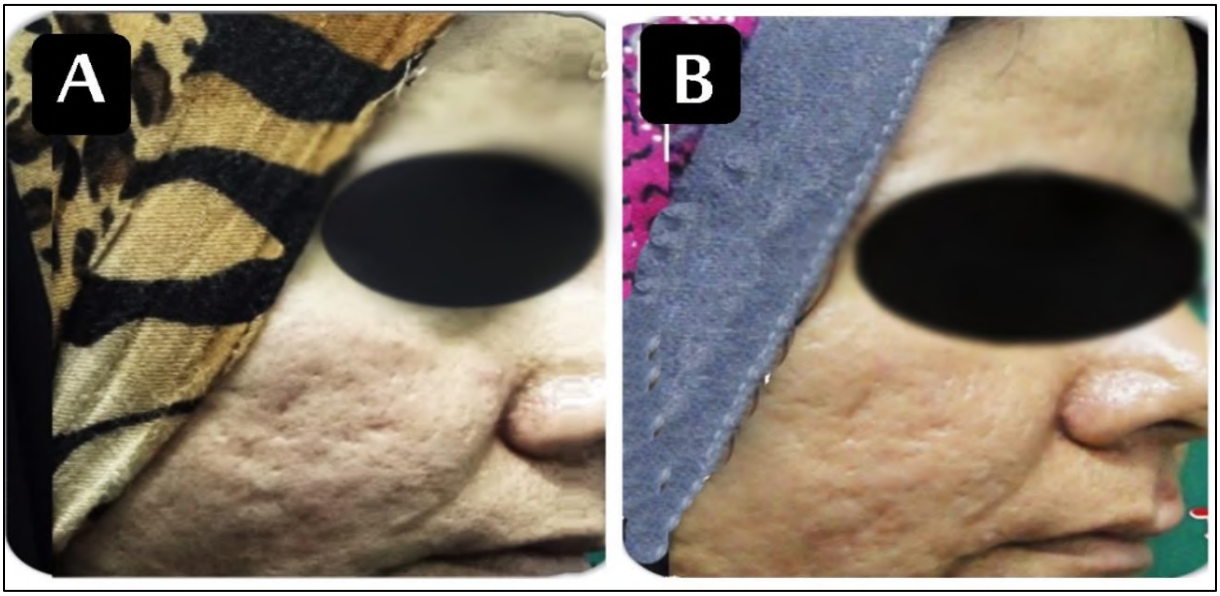


Figure (3): 27 years old female Patient with acne scars: before treatment (A) and 3 months after treatment (B)

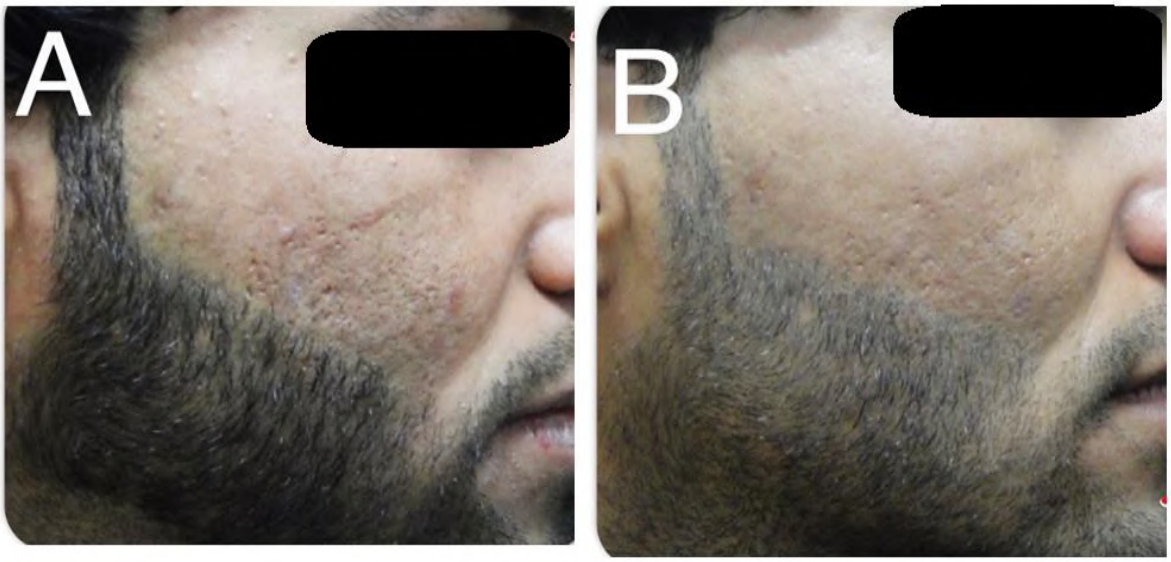


Figure (4): 28 years old male Patient with acne scars: before treatment (A) and 3 months after treatment (B)

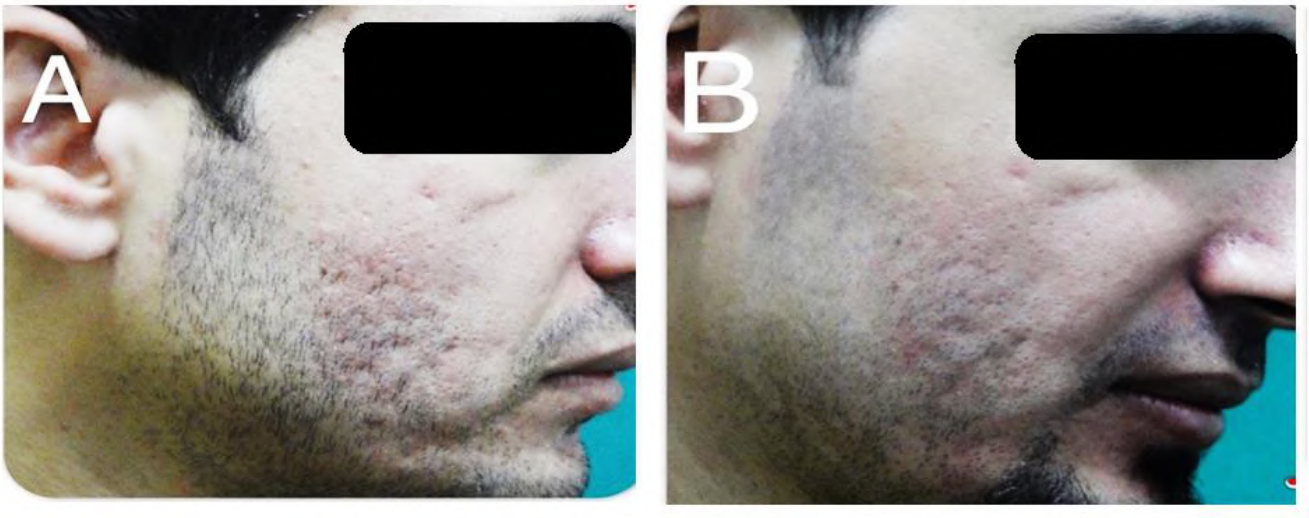


Figure (5): 22 years old male Patient with acne scars: before treatment (A) and 3 months after treatment (B)

4. DISCUSSION

Acne and post-acne scars remain among the most pressing and significant health problems of our time globally. The development of new methodological approaches to the treatment of acne and post-acne scars, leading dermatologists and scientists to escalating searching for an optimal method with lower adverse effect and high satisfactory to the patients. From other point of view, Acne scars, being a cosmetic defect, cause psychological and social consequences and negatively affect the quality of life of patients. The medical and social significance of post-acne scars is due to the high prevalence rates among young people, long-term course and stigmatization [7,30].

The relevance of treating atrophic post-acne scars is highlighted by the high rate of medical consultations among young, socially active individuals seeking scar correction, as well as the lack of clinical guidelines for treating post-acne scars. The existing variety of methods for correcting atrophic post-acne scars varies widely from low-traumatic peeling with hydroxy acids to surgical excision of scar tissue. Laser technologies are considered to be among the most effective. Clinical results of laser therapy vary and are determined by both the technology of exposure, the method of its application, the severity of scars, and their morphological features. A high potential of the ablative erbium laser for the correction of atrophic scars had been approved [8–10,31].

Various approaches to the choice of correction method and procedure protocols are proposed. In practice, the choice of treatment method is determined by the resource availability of a medical organization, the specialty and level of practical skills of the physician, and the financial capabilities of patients, which often leads to unsatisfactory clinical results, low patient satisfaction, prolonged treatment, and increased medical costs [6,14,32]

In 2009, Z. Kutlubay et al. [33] studied the effectiveness of ablative fractional erbium laser resurfacing in a group of 128 patients aged between 22-40 years with skin phototypes II-V and noted scar smoothing, improved skin color, texture, and relief, and pore narrowing. The result was rated as good in 52.3% of cases, excellent in 14.0%, and satisfactory in 31.0%. Patients subjectively assessed the results as "very satisfied" in 77.3% of cases. Most patients had V- and U-shaped scars. Min et al. (2017) [6] investigated the efficacy of fractional erbium laser ablation on atrophic post-acne scars using the quantitative ECCA acne scar assessment scale.

One month after two fractional treatments, performed 4 weeks apart, they noted a significant improvement in all types of atrophic scars (a 50.0% reduction in the ECCA score), with M-shaped and V-shaped scars responding less well to treatment.

In a retrospective study of the effect of laser therapy on 80 patients with atrophic and hypertrophic post-acne scars, Chathra et al. (2018) [34] noted an improvement in 97.0% of patients after a course of 4 procedures performed at 6-week intervals. Fractional ablation of an erbium laser was used, targeting the bottom of the atrophic scar to stimulate neocollagenesis, and a continuous spot mode was used to smooth out the edges of the scar or the thickness of the hypertrophic scar. The degree of scar changes was assessed using the qualitative and quantitative scales of Goodman and Baron, 2006 [35].

The emergence of new technologies for acne scar correction demonstrates the ongoing search for the optimal treatment method for various types of scars. The development of methodology and standardization of medical procedures is required. Taking into account the most typical clinical and morphological manifestations of scars, an assessment of the effectiveness and safety of methods still required to achieve predictable correction results among Iraqi patients. In the present study, 17 Iraqi patients (9 males and 8 females) were included in the study and treated with 2940 nm ablative non-fractional Er: YAG laser therapy

Theoretically, the mechanism of the action of laser resurfacing includes tissue ablation, immediate collagen shrinkage, and dermal collagen remodeling. As in CO2 laser, the targeted chromosphores of the Er: YAG laser are water but there is 16 times more energy absorption. This provides a more precise ablation of skin with minimal thermal damage to the surrounding tissues [28,36]. However, immediate collagen contraction is only about 1–4%, and long-term collagen remodeling ranges from 0–14% [37].

Jeung-Tae Jeong et al. used a dual-mode Er: YAG laser system for resurfacing of pitted, facial acne scars. Two passes in ablation mode at 17.5 J/cm2 were used to remove the whole epidermis followed by two passes of the ‘‘mixed mode,’’ which consists of simultaneous passing of both the ablation mode at 17.5 J/cm2 and coagulation mode at 12.5 J/cm. A final pass in ablation mode at 17.5 J/cm2 was used . The results after 3 months follow up were excellent in (55%) of patients, good in (40%), and fair in (5%).

Regarding the adverse effects, Jeong et al. [38] reported erythema in all patients, and it was lasted for more than 3 months in half of these cases, on the other hands, the authors, found post-inflammatory hyperpigmentation in 60% of cases while 5% of their patients had hypopigmentation and 35% showed acne flare up

Compared to Jeong et al. study[38], we achieved less clinical improvement and much less adverse effects. This may be due to higher fluence and more passes used in the previous study. Our improvement rate was higher than that reported by Goldust and Raghifar [39], nonetheless, they reported lower rate of side effects compared to ours, this is may be attributed to the total epidermal ablation done by non-fractional mode comparing with fractional mode.

In a study conducted by Manuskiatti et al. [40] in 2010, they used ablative fractional CO2 laser for treatment of acne scars and obtained an improvement degree better than ours, this discrepancy may be due to the fact that collagen contraction and neocollagenesis are better with CO2 laser compared to our used modality and the difference in the follow-up period where Manuskiatti et al.[40] followed their cases for longer duration than we did with our cases.

Regarding the side effects reported among our patients, were much less frequent compared to other studies using other devices and technique, and this because the CO2 laser is well-known to produce more thermal damage than Er: YAG on the tissues surrounded the target chromophore. In a previous Iraqi study, Al-Dhalimi and Jaber tried the 1540 nm laser as an approach for treatment among Iraqi patients with atrophic facial scars and reported an improvement rate of 57.9% after 6 months follow up. With regards to the adverse outcomes, Al-Dhalimi and Jaber [41] did not report any significant complications or side effect among their cases except mild erythema and burning sensations after treatment sessions. However, among our cases, in the present study we achieved better improvement but more side effects than the previous study and this is may be attributed to the total epidermal ablation done by Er: YAG laser comparing with Erbium: glass laser in which the epidermis is preserved.

5. CONCLUSIONS

Erbium: YAG laser (2940 nm) is an effective and safe method for treatment of atrophic facial acne scars among Iraqi patients, it offers high improvement rates with no serious complications or side effects. Therefore, we recommend conducting further studies with larger sample size, longer follow-up duration, trying more treatment sessions to assess the long-term efficacy of this treatment approach and further improvement with longer time. Also, it is recommended to compare fractional against non-fractional modes of Er:YAG laser in the treatment of acne scars.

Ethical Approval:

All ethical issues were approved by the college ethical and scientific committee as well as all patients signed an informed consent prior to start the treatment. Data collection and patient's enrollment were in accordance with Declaration of Helsinki of World Medical Association, 2013 for the ethical principles of researches involving human.

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