Am J Transl Res 2025;17(1):116-124
www.ajtr.org /ISSN:1943-8141/AJTR0161453

Original Article

Efficacy of fractional laser combined with bipolar radiofrequency in the treatment of atrophic facial acne scaring

Chaoqin Long*, Yan Xu*, Qiao Lin*, Ping Wang, Qian Zhang, Xia Hu, Xingjiao Liu

*Department of Dermatology and Cosmetology, The People's Hospital of Chongqing Liangping District, Chongqing 405299, China. *Equal contributors and co-first authors.*

Received October 25, 2024; Accepted December 24, 2024; Epub January 15, 2025; Published January 30, 2025

Abstract: Objective: To evaluate the clinical efficacy of fractional laser treatment combined with bipolar radiofrequency for improving atrophic facial acne scars. Methods: The clinical data of patients with atrophic facial acne scars treated in the Dermatology Department of The People's Hospital of Chongqing Liangping District from October 2022 to 2023 were retrospectively analyzed. The patients were divided into two groups based on treatment methods: the single intervention group (Group A, n=25) and the combined intervention group (Group B, n=25). Group A received bipolar radiofrequency therapy only, with a treatment cycle of 4 weeks and 4 cycles per treatment course. Group B received combination treatment, starting with carbon dioxide (CO_2) laser therapy for 2 weeks, followed by bipolar radiofrequency therapy for 2 weeks, alternating between the two modalities for 4 cycles per treatment course. Six months post-treatment, three doctors performed a blinded evaluation of facial photos from both groups using the Echelle d'evaluation clinique des cicatrices d'acne (ECCA) to assess clinical efficacy. Outcome measures included changes in scar texture and facial atrophy, adverse reactions, and patient satisfaction. Results: The facial acne scars in both groups were classified as type III-IV before surgery. Post-treatment follow-up showed significant improvements in scar texture and atrophy in both groups. Group B demonstrated superior treatment outcomes compared to Group A. Specifically, the incidence of edema and pigmentation was lower in group B with a shorter duration of edema, faster wound healing, and reduced rest time compared to group A. Patient satisfaction was also higher in group B. Conclusion: Fractional laser treatment combined with bipolar radiofrequency therapy is an effective combination for patients with atrophic acne scars, offering minimal side effects and enhanced patient satisfaction.

Keywords: Fractional laser, bipolar radiofrequency, atrophic acne scar, adverse reactions, patient satisfaction

Introduction

Atrophic scars are a common and permanent complication of acne vulgaris, affecting 11%-14% of individuals and significantly impacting their quality of life [1]. Scars are formed during the healing process of acne and its severity is often associated with the extent of acne and delayed treatment, affecting at least 95% of acne patients [2, 3]. Atrophic scars are characterized by depressions in the facial skin due to defects in subcutaneous tissue, which result from the loss and disorganization of dermal collagen and elastin [4]. Acne scars are classified into three types based on severity (depth and size of damage): icepick, boxcar and rolling types [5]. Advances in medical technology have led to a variety of treatment options for post-acne atrophic scars, such as microdermabrasion, chemical exfoliation, tissue filling, and ablation lasers. While these methods offer varying degrees of improvement, they are often accompanied by adverse reactions [6-8]. Nevertheless, photoelectric treatments remains the most commonly selected option by clinicians.

Ultrapulsed carbon dioxide (CO_2) laser treatment was once considered the most effective treatment for atrophic acne scars [9]. While effective in reshaping skin contours and improving scar texture, CO_2 laser treatment can lead to

https://doi.org/10.62347/PQOJ2511

side effects such as redness, burning sensation, post-inflammatory pigmentation, and scar formation in the treatment area, which can diminish its overall efficacy [10, 11]. Due to these side effects, the use of fractional CO_2 lasers for atrophic scars has been limited. Therefore, combining fractional CO_2 laser treatment with other modalities has been proposed to promote wound healing, minimize adverse reactions, and enhance treatment satisfaction [12]. Many studies have shown that CO_2 laser combined with other treatments or medications yields significantly better outcomes in improving skin lesions and is generally safer than single-treatment approaches [12, 13]. This has led many researchers to advocate for comprehensive treatment options for atrophic scars.

Radiofrequency radiation is a non-ionizing electromagnetic radiation with a frequency range of 3 kHz to 300 GHz [14]. Unlike most lasers that target specific chromophores, radiofrequency radiation interacts with the electrical properties of the target tissue and is independent of chromophores, making it safer for all skin types [15, 16]. Clinical studies have demonstrated the efficacy and safety of bipolar radiofrequency treatment in Asian populations [17, 18]. However, there is limited literature on its use in treating atrophic scars. A randomized, sequence-blind evaluation showed no significant difference between CO_2 laser treatment and radiofrequency treatment in improving atrophic scars; however, the recovery time for skin erythema and desquamation after radiofrequency treatment was relatively short, indicating good therapeutic effects [19]. Other studies have shown that CO_2 laser combined with bipolar radiofrequency treatment effectively improves facial defects and reduces skin pigmentation, with few side effects [20].

This study aims to evaluate the clinical efficacy of fractional laser combined with bipolar radiofrequency in the treatment of facial atrophic acne scars in Chinese patients. Additionally, it seeks to explore the advantages and safety profile of this combined treatment, with the goal of providing a new therapeutic approach for clinical dermatology in managing atrophic facial acne scarring.

Data and methods

General information

The medical records of all patients with atrophic facial acne scarring treated from October 2022 to October 2023 at the Dermatology Department of The People's Hospital of Chongqing Liangping District were collected. After initial screening, inappropriate cases were excluded. A total of 65 patients with atrophic facial acne scars were initially identified, and after re-evaluating the basic data, 50 patients were included in the study. These patients were divided into two groups: the single intervention group (Group A, n=25) and the combined intervention group (Group B, n=25). The study procedure is depicted in **Figure 1**.

Inclusion criteria: (1) Patient aged 18 years or above and those who met the diagnostic criteria for acne scars; (2) Patients with facial Fitzpatrick skin type II-IV, with atrophic acne scars lasting longer than 1 year; (3) Patients who had completed at least 1 treatment, including bipolar radiofrequency therapy and CO_2 laser therapy; (4) No topical pharmaceutical preparations were used before or after treatment, including oral anticoagulants, antibiotics, glucocorticoids, retinoids and photosensitive drugs; (5) Complete patient data, including facial pictures, ECCA scores, VAS scores and other data. Exclusion criteria: (1) Missing data before or after treatment; (2) Presence of other bacterial, viral, primary or secondary progressive skin lesions on the face.

Treatment methods

The treatment plan was proposed by the dermatology outpatient physician based on the diagnosis and finalized after consultation with the patient. Patients in group A were treated with bipolar radiofrequency only, with treatments scheduled 4 weeks apart, for a total of 4 cycles per course. Patients in group B first underwent CO_2 laser treatment, followed by bipolar radiofrequency therapy after 2 weeks. The two treatments alternated, with 4 cycles in total per course. The CO_2 laser system has a power range of 12-14 W and a microbeam energy of 48-56 mJ/cm^2. The minimum energy level was used at the first treatment, with subsequent treatments using progressively higher

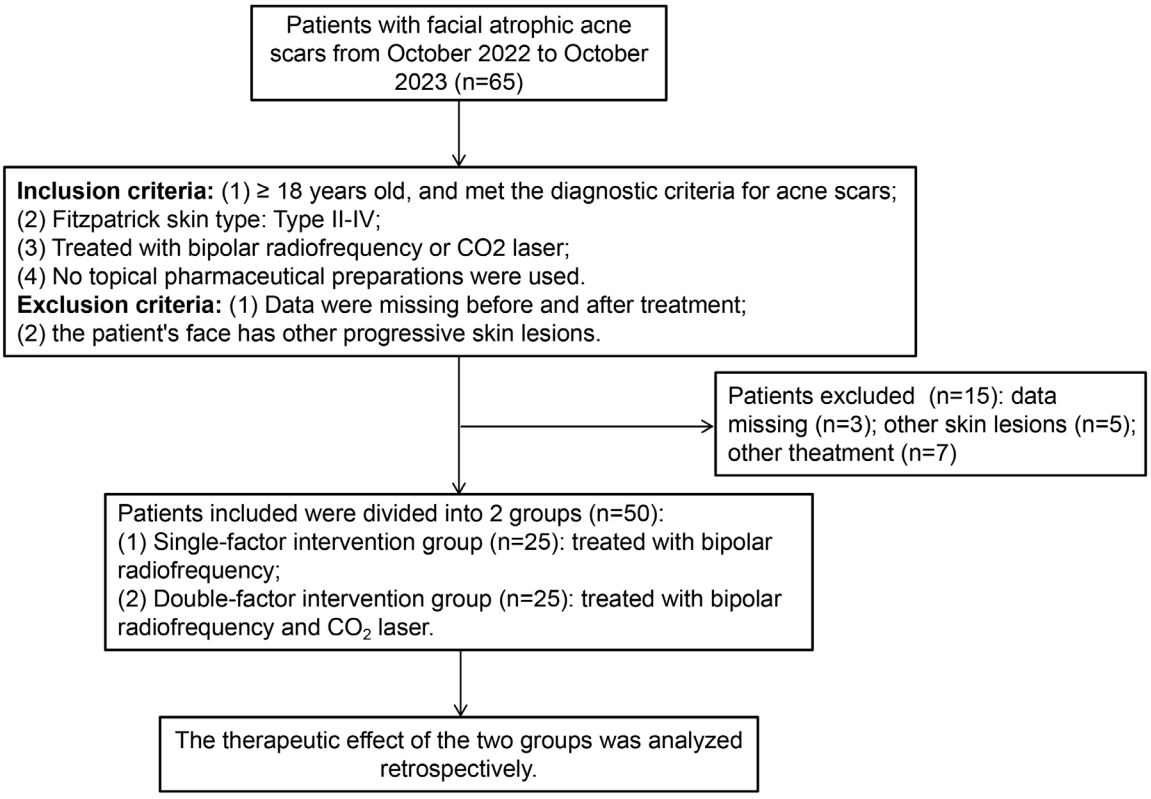

Figure 1. Study flow chart.

Table 1. Echelle d'evaluation clinique des cicatrices d'acne (ECCA) scale

Weight score (a)	(1) V-shaped scar: diameter < 2 mm, punctate, a=15
	(2) U-shaped scar: diameter 2-4 mm, steep edge, a=20
	(3) W-shaped scar: diameter > 4 mm, superficial and irregular, a=25
Semi-quantitative scoring (b)	(1) b=0, no scar
	(2) b=1, the number of scars < 5
	(3) b=2, the number of scars is 5-20
	(4) b=3, the number of scars > 20

Note: ECCA score = a × b. ECCA, Echelle d'evaluation clinique des cicatrices d'acne.

Table 2. Comparison of baseline data between the two groups

	Group A (n=25)	Group B (n=25)	χ^2/t	P
Gender			0.0805	0.7766
Male	13	14		
Female	12	11		
Average age (years)	25.31±5.98	25.67±6.11	0.5372	0.9454
Average duration of disease (years)	2.34±0.98	2.45±1.03	0.5877	0.8365
Fitzpatrick skin typing			0.0821	0.7745
III	15	14		
IV	10	11		

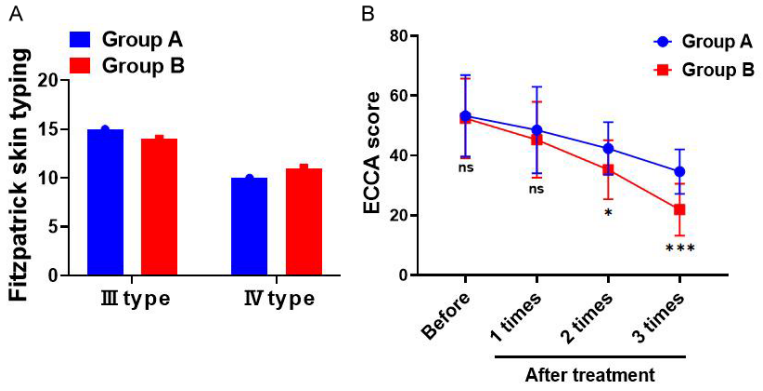

Figure 2. Comparison of baseline skin type and ECCA scores between the two groups. A. Comparison of skin type before treatment; B. Comparison of ECCA scores between the two groups before and after treatment. $^{ns}P > 0.05$, $^{*}P < 0.05$, $^{***}P < 0.001$. ECCA: Echelle d'evaluation clinique des cicatrices d'acne.

Table 3. Comparison of ECCA scores between the two groups before and after treatment ($\bar{x} \pm s$)

	Before treatment	Post-first treatment	Post-second treatment	Post-third treatment
Group A	53.28±13.61	48.53±14.45	42.39±8.77	34.65±7.45
Group B	52.46±13.31	45.29±12.68	35.29±9.84	21.92±8.67
t	0.753	0.985	1.018	4.859
P	0.568	0.237	0.033*	0.001***

Note: *P < 0.05, ***P < 0.001. ECCA, Echelle d'evaluation clinique des cicatrices d'acne.

Figure 3. Acne photos of a typical cases in Group B before and after treatment. A. Before treatment: multiple atrophic scars on the face, with obvious pigmentation at the scar site; B. After treatment: smoother atrophic scars, with reduced pigmentation at the scar site.

energy levels. The bipolar radiofrequency system delivers energy in a segmented manner and used a disposable treatment head with eight rows and eight columns of parallel, bipolar gold-plated electrode needles. The ablation mode was set at 5-10% coverage with 50-62 mJ/needle. A 2.5% lidocaine solution was used as a local anesthetic to the treatment area 1 h before the procedure.

Evaluation

Treatment data were collected, including pictures of facial acne, acne morphology, Echelle d'evaluation clinique des cicatrices d'acne (ECCA) score, VAS score, adverse reactions and other relevant information. The therapeutic effects of the two groups were evaluated.

Evaluation indicators included: (1) Treatment efficacy: Facial photos were taken before treatment, after the first treatment, second treatment, and third treatment. ECCA scores were recorded either from the patient's outpatient profile or directly during the study. The ECCA scoring criteria are shown in **Table 1**. Treatment efficacy was also assessed based on the degree of facial improvement, categorized as: recovery, significantly effective, effective, and ineffective. (2) Adverse reactions: Adverse reactions during treatment were documented, including edema and its duration, hyperpigmentation, scar formation, wound healing time, rest time, and postoperative pain. (3) Satisfaction: Patient satisfaction with treatment outcome was assessed based on a post-treatment evaluation in the hospital system. Satisfaction scores ranged from 0 to 10, with scores of 8 or above classified as "very satis-

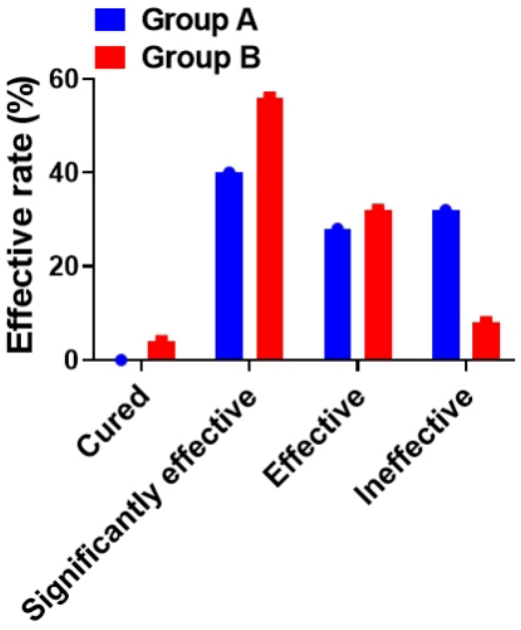

Figure 4. Comparison of treatment efficacy between the two groups.

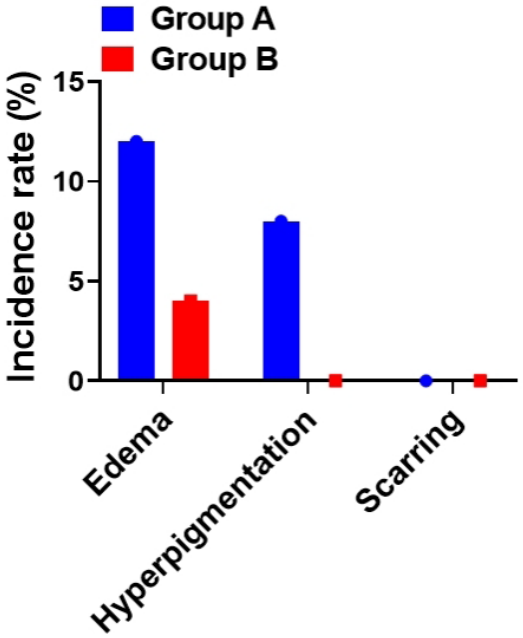

Figure 5. Comparison of safety profile between the two modalities.

fied", scores of 6 or above as "generally satisfied", and scores below 6 as "dissatisfied".

Statistical analysis

SPSS 20.0 was used for data analysis. The Wilcoxon rank sum test and paired t-test were used to analyze the significance of differences in measured parameters before and after the intervention treatment. All data are shown as mean ± standard error. Chi-square test was used to analyze the difference of counting data between the two groups. $P < 0.05$ was considered statistically significant.

Results

Comparison of baseline characteristics and ECCA scores between the two groups

A total of 50 cases were included in this study. Group A consisted of 13 male patients and 12 female patients, with an average age of (25.31±5.98) years and an average disease duration of (2.34±0.98) years. Group B comprised 14 male patients and 11 female patients, with an average age of (25.67±6.11) years and an average disease duration of (2.45±1.03) years. As shown in **Table 2** and **Figure 2A**, there was no significant difference in baseline data between the two groups, including Fitzpatrick skin classification ($P > 0.05$).

After treatment, ECCA scores in both groups decreased significantly. Following the third treatment, ECCA scores in Group B (21.92± 8.67) were significantly lower than those in Group A (34.65±7.45) ($P < 0.001$, **Table 3** and **Figure 2B**), indicating that the combined intervention was more effective than single intervention.

Comparison of therapeutic efficacy between the two groups

The therapeutic effects of typical cases are shown in **Figure 3**. The total effective rate in Group B (92%) was significantly higher than that in Group A (68%) ($P < 0.05$) (**Figure 4**).

Comparison of safety profile between the two groups

No scarring occurred after treatment in either group. The incidence of edema and hyperpigmentation in Group B was significantly lower than that in Group A ($P < 0.05$) (**Figure 5**).

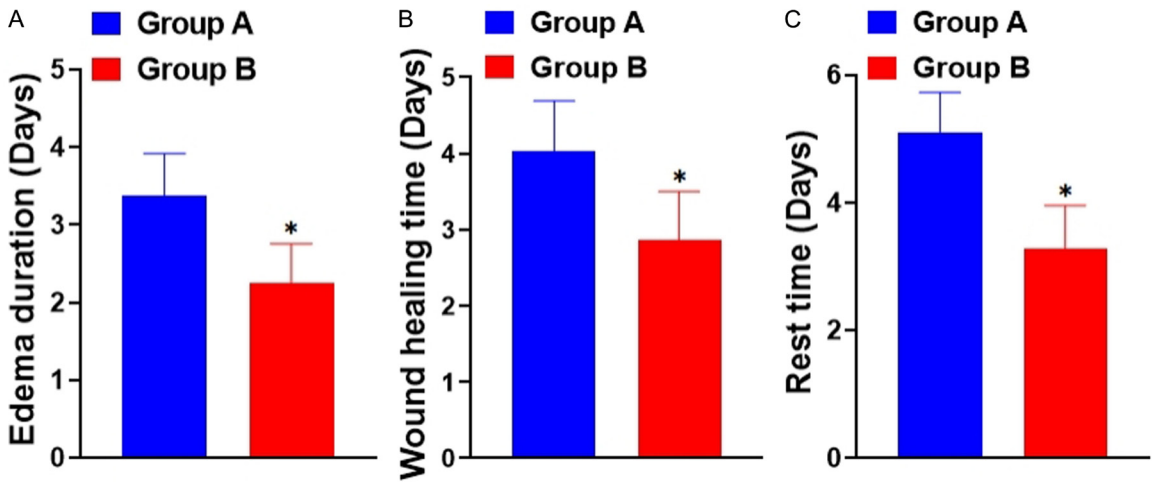

Figure 6. Comparison of recovery indicators between the two groups. A. Comparison of postoperative edema duration; B. Comparison of wound healing time; C. Comparison of rest time. $^{*}P < 0.05$.

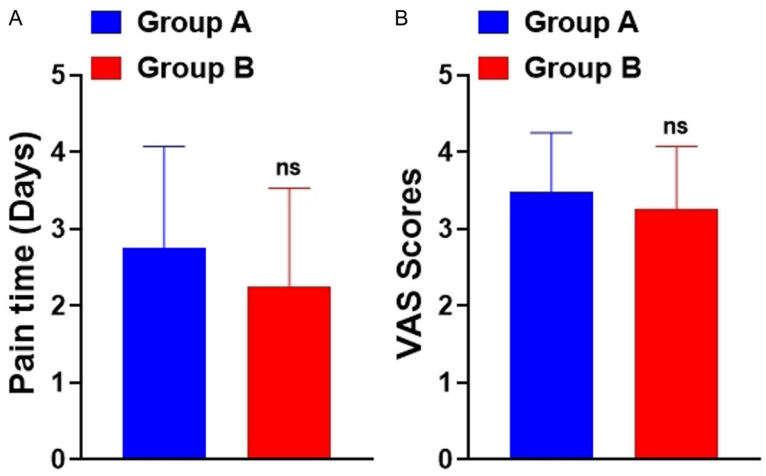

Figure 7. Comparison of facial tolerance between the two groups. A. Comparison of postoperative facial pain duration between the two groups; B. Comparison of visual analog scale (VAS) scores between the two groups. $^{ns}P > 0.05$.

Comparison of recovery progress between the two groups

The duration of edema, wound healing time, and patient rest time were significantly lower in Group B than those in Group A ($P < 0.05$) (**Figure 6A-C**), indicating faster recovery in Group B.

Comparison of facial tolerance between the two groups

No significant differences were observed in postoperative facial pain duration or VAS scores between the two groups (all $P > 0.05$) (**Figure 7A**, **7B**).

Comparison of patient satisfaction between the two groups

The overall satisfaction of patients in Group B (96%) was significantly higher than that in Group A (84%) ($P < 0.05$) (**Figure 8**).

Discussion

Acne vulgaris can lead to various forms of atrophic acne scars, with severity depending on the underlying inflammation [21]. Acne scars consist of collagen fibers deep in the dermis, and atrophic acne scarring involves atrophy and fibrosis of these collagen fibers. The production of new collagen and its remodeling are believed to improve the appearance of acne scars [22, 23]. Histologically, collagen fibers in the dermis are irregularly arranged and thicker, often matching the thickness of the surrounding epidermal tissue. Therefore, effective treatment requires deeply addressing the depressed areas while preserving the surrounding normal tissue [24]. Numerous clinical studies have shown that ablative lasers, compared to non-ablative lasers, are more effective in treating acne atrophic scarring, despite the longer treatment course and less favorable outcomes associated with non-ablative lasers [25].

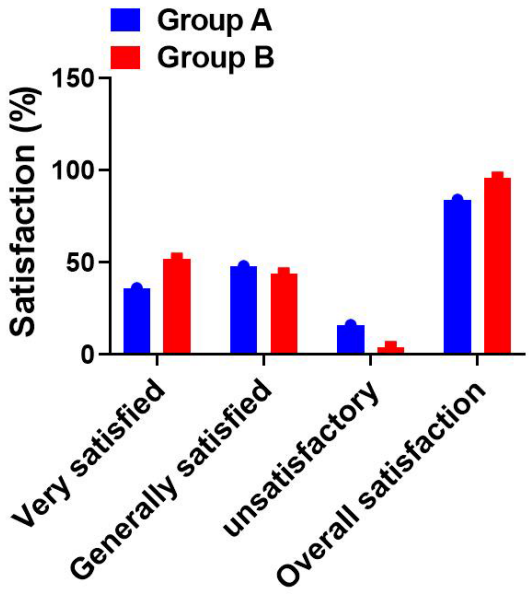

Figure 8. Comparison of patient satisfaction between the two groups.

In this study, we comparatively evaluated the efficacy and adverse reactions of bipolar radiofrequency therapy alone and CO_2 laser therapy combined with bipolar radiofrequency therapy. The results showed that both treatments improved scar texture and reduced atrophy. In line with previous literature, CO_2 laser therapy and bipolar radiofrequency therapy are both effective treatment methods for atrophic scars and have good effects on scars [26, 27]. However, the combined treatment demonstrated significantly better clinical efficacy, with milder adverse reactions, such as edema and pigmentation. Furthermore, patients in the two-factor group experienced faster postoperative recovery and reported higher self-assessment scores for scar texture improvement.

It is well established in the literature that CO_2 laser treatment is effective for acne scars by generating thermal damage to the skin, which stimulates dermal cells to produce excessive collagen and undergo remodeling. This process promotes tissue regeneration around the wound and facilitates skin repair. However, the high energy of the fractional CO_2 laser can also cause damage to the skin, leading to adverse effects such as redness and burning sensation [28, 29]. Previous studies have shown that bipolar radiofrequency treatment delivers energy deeper into the dermis, heating the targeted area to cause controlled damage, which triggers a wound healing response. This, in turn, stimulates collagen fiber remodeling deep within the dermis, while causing minimal damage to the superficial skin layers [30]. Although the mechanisms of these two treatments are similar, their combined use yields remarkable therapeutic effects. The proposed mechanism for the improved efficacy of this combination involves initially using the fractional CO_2 laser to exfoliate surface scars and stimulate collagen regeneration. This creates a potent treatment effect. Following this, bipolar radiofrequency therapy is applied, further promoting collagen regeneration in scar tissue, reshaping collagen fibers and elastin, and enhancing hyaluronic acid deposition to fill the depressions of atrophic scars. Bipolar radiofrequency also aids in repairing skin damage caused by CO_2 laser treatment. Alternating between these two treatments minimizes thermal damage to the skin, enhancing the overall treatment effect. Therefore, the combined use of CO_2 laser and bipolar radiofrequency therapy produces better results than CO_2 laser treatment alone. In early clinical studies, scholars have also explored the use of CO_2 fractional lasers in combination with radiofrequency to treat atrophic acne scars and photoaging. These studies have shown that this combination reduces the number of treatment sessions required while achieving superior results and significantly fewer side effects [31]. Consistent with the literature, it can be concluded that the combination of CO_2 laser and bipolar radiofrequency therapy offers deeper healing, improved treatment outcomes, a stable curative effect, and minimal side effects [32].

The results of this study suggest that fractional laser usage combined with bipolar radiofrequency treatment is effective in treating atrophic acne scars, with fewer side effects and improved patient satisfaction. The main limitation of this study is the small sample size. Further research with a larger cohort, a broader range of treatment parameters, and a longer follow-up period is necessary to fully assess the long-term efficacy of the combined fractional laser and bipolar radiofrequency treatment.

Disclosure of conflict of interest

None.

Address correspondence to: Ping Wang, Department of Dermatology and Cosmetology, The People's Hospital of Chongqing Liangping District, Chongqing 405299, China. Tel: +86-023-53222359; E-mail: 13617600423@163.com

References

[1] Boen M and Jacob C. A review and update of treatment options using the acne scar classification system. Dermatol Surg 2019; 45: 411-422.

[2] Sitohang IBS, Sirait SAP and Suryanegara J. Microneedling in the treatment of atrophic scars: a systematic review of randomised controlled trials. Int Wound J 2021; 18: 577-585.

[3] Sadick NS and Cardona A. Laser treatment for facial acne scars: a review. J Cosmet Laser Ther 2018; 20: 424-435.

[4] Moon J, Yoon JY, Yang JH, Kwon HH, Min S and Suh DH. Atrophic acne scar: a process from altered metabolism of elastic fibres and collagen fibres based on transforming growth factor-beta1 signalling. Br J Dermatol 2019; 181: 1226-1237.

[5] Li X, Fan H, Wang Y, Sun C, Yang X, Ma X and Jiao J. Fractional carbon dioxide laser combined with subcision for the treatment of three subtypes of atrophic acne scars: a retrospective analysis. Lasers Med Sci 2023; 38: 195.

[6] Nobari NN, Tabavar A, Sadeghi S, Dehghani A, Kalantari Y, Ghassemi M, Atefi N and Goodarzi A. A systematic review of the comparison between needling (RF-needling, meso-needling, and micro-needling) and ablative fractional lasers (CO(2), erbium YAG) in the treatment of atrophic and hypertrophic scars. Lasers Med Sci 2023; 38: 67.

[7] Abdel Hay R, Shalaby K, Zaher H, Hafez V, Chi CC, Dimitri S, Nabhan AF and Layton AM. Interventions for acne scars. Cochrane Database Syst Rev 2016; 4: CD011946.

[8] Mohammed GF and Al-Dhubaibi MS. Triple steps acne scar revision technique: a new combination therapeutic modality for atrophic acne scars. J Cosmet Dermatol 2022; 21: 4659-4668.

[9] Xu Y and Deng Y. Ablative fractional CO2 laser for facial atrophic acne scars. Facial Plast Surg 2018; 34: 205-219.

[10] Banihashemi M, Nahidi Y, Maleki M, Esmaily H and Moghimi HR. Efficacy of fractional CO2 laser in treatment of atrophic scar of cutaneous leishmaniasis. Lasers Med Sci 2016; 31: 733-739.

[11] Hedelund L, Haak CS, Togsverd-Bo K, Bogh MK, Bjerring P and Haedersdal M. Fractional CO2 laser resurfacing for atrophic acne scars: a randomized controlled trial with blinded response evaluation. Lasers Surg Med 2012; 44: 447-452.

[12] Ge YN, Pan HH, Zhao JB and Chen Y. Clinical effects of fractional carbon dioxide laser combined with minimally invasive scar release in the treatment of post-acne atrophic scars. Zhonghua Shao Shang Yu Chuang Mian Xiu Fu Za Zhi 2023; 39: 53-58.

[13] Li X, Fan H, Wang Y, Sun C, Yang X, Ma X and Jiao J. Fractional carbon dioxide laser combined with subcision for the treatment of three subtypes of atrophic acne scars: a retrospective analysis. Lasers Med Sci 2023; 38: 195.

[14] Tan MG, Jo CE, Chapas A, Khetarpal S and Dover JS. Radiofrequency microneedling: a comprehensive and critical review. Dermatol Surg 2021; 47: 755-761.

[15] Weiner SF. Radiofrequency microneedling: overview of technology, advantages, differences in devices, studies, and indications. Facial Plast Surg Clin North Am 2019; 27: 291-303.

[16] Austin GK, Struble SL and Quatela VC. Evaluating the effectiveness and safety of radiofrequency for face and neck rejuvenation: a systematic review. Lasers Surg Med 2022; 54: 27-45.

[17] Suh DH, Cho M, Kim HS, Lee SJ, Song KY and Kim HS. Clinical and histological evaluation of microneedle fractional radiofrequency treatment on facial fine lines and skin laxity in Koreans. J Cosmet Dermatol 2023; 22: 1507-1512.

[18] Kaminaka C, Furukawa F and Yamamoto Y. Long-term clinical and histological effects of a bipolar fractional radiofrequency system in the treatment of facial atrophic acne scars and acne vulgaris in Japanese patients: a series of eight cases. Photomed Laser Surg 2016; 34: 657-660.

[19] Zhang Z, Fei Y, Chen X, Lu W and Chen J. Comparison of a fractional microplasma radio frequency technology and carbon dioxide fractional laser for the treatment of atrophic acne scars: a randomized split-face clinical study. Dermatol Surg 2013; 39: 559-566.

[20] Campolmi P, Bonan P, Cannarozzo G, Bruscino N and Moretti S. Efficacy and safety evaluation of an innovative CO2 laser/radiofrequency device in dermatology. J Eur Acad Dermatol Venereol 2013; 27: 1481-1490.

[21] Kurokawa I, Layton AM and Ogawa R. Updated treatment for acne: targeted therapy based on pathogenesis. Dermatol Ther (Heidelb) 2021; 11: 1129-1139.

[22] Kwon HH, Yang SH, Lee J, Park BC, Park KY, Jung JY, Bae Y and Park GH. Combination treatment with human adipose tissue stem cell-derived exosomes and fractional CO2 laser for acne scars: a 12-week prospective, double-

blind, randomized, split-face study. Acta Derm Venereol 2020; 100: adv00310.
[23] Pavlidis AI and Katsambas AD. Therapeutic approaches to reducing atrophic acne scarring. Clin Dermatol 2017; 35: 190-194.
[24] Fusano M and Bencini PL. Microneedle fractional radiofrequency for atrophic acne scars: in vivo evaluation of results by 3D analysis and reflectance confocal microscopy. Dermatol Ther 2022; 35: e15454.
[25] Kim EY, Wong JH, Hussain A and Khachemoune A. Evidence-based management of cutaneous scarring in dermatology part 2: atrophic acne scarring. Arch Dermatol Res 2023; 316: 19.
[26] Magnani LR and Schweiger ES. Fractional CO2 lasers for the treatment of atrophic acne scars: a review of the literature. J Cosmet Laser Ther 2014; 16: 48-56.
[27] Dayan E, Chia C, Burns AJ and Theodorou S. Adjustable depth fractional radiofrequency combined with bipolar radiofrequency: a minimally invasive combination treatment for skin laxity. Aesthet Surg J 2019; 39: S112-S119.
[28] Pan Z, Tang Y, Hua H, Hou Z and Zhou B. "Multiple Mode Procedures" of ultra-pulse fractional CO(2) laser: a novel treatment modality of facial atrophic acne scars. J Clin Med 2023; 12: 4388.
[29] Majid I and Imran S. Fractional CO2 laser resurfacing as monotherapy in the treatment of atrophic facial acne scars. J Cutan Aesthet Surg 2014; 7: 87-92.
[30] Labadie JG, Chilukuri S, Cohen J, Kilmer S, Lupo M, Rohrich R and Dover JS. Noninvasive hands-free bipolar radiofrequency facial remodeling device for the improvement of skin appearance. Dermatol Surg 2023; 49: 54-59.
[31] Cameli N, Mariano M, Serio M and Ardigo M. Preliminary comparison of fractional laser with fractional laser plus radiofrequency for the treatment of acne scars and photoaging. Dermatol Surg 2014; 40: 553-561.
[32] Gotkin RH and Sarnoff DS. A preliminary study on the safety and efficacy of a novel fractional CO(2) laser with synchronous radiofrequency delivery. J Drugs Dermatol 2014; 13: 299-304.