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Comparative evaluation of punch elevation combined with fractional CO2 laser resurfacing versus fractional CO2 laser alone in the treatment of atrophic acne scars

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***Abstract*---Background:** Acne vulgaris is a chronic inflammatory skin condition that often results in atrophic scarring, impacting physical appearance and mental health. This study aims to evaluating the potential effect of combining punch elevation with fractional CO_2 laser resurfacing versus laser treatment alone for moderate to severe atrophic acne scars. **Patients and Methods:** A split-face comparative study involved 20 adults aged 18 to 55 with moderate to severe atrophic acne scars. One side received punch elevation followed by fractional CO_2 laser resurfacing, while the other side received fractional CO_2 laser treatment alone. Clinical assessments included Goodman and Baron's grading scale and patient satisfaction ratings. Histopathological evaluations analyzed fibroblast activity, epidermal

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thickness, and collagen composition. **Results:** The combined treatment significantly improved scar severity, with a mean reduction of 44.40% compared to 18.89% for the laser-only group ($p < 0.001$). Histopathological analysis showed increases in fibroblast activity (5.87% to 19.14%, $p < 0.003$) and epidermal thickness (635.65 μm to 1497.35 μm, $p < 0.001$). Patient satisfaction was higher for the combined approach (6.80 ± 1.2) versus laser-only treatment (5.65 ± 1.3, $p < 0.001$). **Conclusion:** Combining punch elevation technique with fractional CO_2 laser resurfacing enhances treatment outcomes for atrophic acne scars, offering a promising advancement in management strategies.

***Keywords*---**Scars, Punch elevation, Acne, Fractional CO_2.

Introduction

Acne vulgaris is considered a chronic inflammatory condition that affects the pilosebaceous units of the skin, predominantly seen on the face, neck, chest, and upper back [1]. While acne is most common during adolescence, affecting 35% to 90% of individuals, approximately 12% of cases persist into adulthood, causing not only physical disfigurement but also significant psychological and social implications [2]. Acne can lead to permanent scarring, with atrophic scars being the most prevalent, affecting 47% of individuals with acne scars. These scars are categorized into three types: icepick, rolling as well as boxcar scars [3].

The management of atrophic acne scars is complex and often requires a multi-faceted approach. Current treatment options include medical management with topical retinoids, surgical procedures such as punch excision, skin grafting, in addition to subcision, and procedural techniques like microdermabrasion, several concentration of chemical peels, and microneedling (percutaneous collagen induction) [4].

Among the various methods, fractional CO_2 laser resurfacing has emerged as the golden standard for treating atrophic acne scars. This laser technology works by ablating microcolumns of damaged skin while tightening underlying collagen, allowing for faster healing and fewer complications due to untreated surrounding tissue [5].

Punch elevation, another surgical technique used for atrophic scars, involves the use of a circular blade to lift the base of the scar while preserving the surrounding skin. This technique is effective in reducing the pitted appearance of scars, leading to a more even skin texture [6].

Given the individual success of both fractional CO_2 laser and punch elevation techniques, it is hypothesized that combining these treatments could result in enhanced outcomes for patients with atrophic acne scars [7]. The present study aims to compare the efficacy of combining punch elevation with fractional CO_2 laser resurfacing versus using fractional CO_2 laser resurfacing alone.

Materials and Methods

Study Design

This split-face comparative study was conducted on 20 adult patients (8 males and 12 females) aged 18 to 55 years, who presented with moderate to severe atrophic acne scars. The study was approved by the Research Ethical Committee of the Faculty of Medicine, Ain Shams University, and all ethical guidelines for human research were followed. Written informed consent was obtained from all participants after they were provided with full details of the procedure, possible side effects, and photographic documentation.

Inclusion Criteria

Patients suffering from moderate to severe atrophic post-acne scars, classified based on Goodman and Baron's quantitative grading system [8] and with symmetrical scar distribution on both sides of the face, were included in the study. Skin phototypes II-IV were eligible for inclusion.

Exclusion Criteria

Pregnancy, lactation, active acne, the use of isotretinoin within the past 6 months, active infections or malignancies in the treatment area, bleeding disorders, history of herpes infections, and a history of hypertrophic scars or keloids.

Pre-Treatment Evaluation

All patients underwent a comprehensive medical history and dermatological examination, focusing on acne onset, duration, and previous treatments. Clinical evaluation of the scars was performed via Goodman and Baron's acne scarring grading system, which assesses scar type, severity, and number. Patients' satisfaction with the treatments was evaluated using a visual analog scale (VAS)[9], where 0 indicated no satisfaction and 10 indicated the highest level of satisfaction.

Photographic documentation was carried out using a Sony Cyber-shot DSC-W320 camera (14.1 MP) before treatment, before each laser session, and four weeks after the final session.

Treatment Protocol

For each patient, one side of the face was treated with fractional CO_2 laser resurfacing alone, while the other side received a combination of punch elevation and fractional CO_2 laser resurfacing. The punch elevation procedure was performed first, using 2.5-3 mm disposable biopsy punches (KAI Medical, Japan), and the elevated scars were covered with sterile strips for 5 days. Five days later, fractional CO_2laser resurfacing was performed on the entire face using the BISON Fire-Xel device (Korea). A second fractional CO_2 laser session was performed four weeks later.

The laser settings were as follows: pulse width 1.106 ms, repeat delay single, overlap 4 times, density 0.8 mm, energy 66.3 mJ/cm², wavelength 10,600 nm, and spot size 300 μm.

Post-Treatment Care

Post-procedural care included the application of SPF 50+ sunscreen and topical antibiotics to prevent secondary infections. Sunscreen was applied daily and reapplied every two hours during sun exposure.

Histomorphometric and Pain Evaluation

Skin biopsies were obtained from a specific scar area before treatment and four weeks after the final session. Histological analysis was performed using H&E, Mallory trichrome, and silver stains to assess epidermal thickness, type I and III collagen fibers, and fibroblast activity (via VEGF expression).

Pain intensity was evaluated using a numerical rating scale (NRS), where patients rated their post-procedural pain from 0 (no pain) to 10 (worst pain imaginable)[10]. Additionally, erythema duration and severity, as well as other complications such as dyspigmentation or scarring, were monitored.

Statistical Analysis

The SPSS version 22.0 for Windows® was used to code, process, and analyze the data that was gathered. The Shapiro Walk test was used to determine whether the data had a normal distribution. Frequencies and relative percentages were used to illustrate the qualitative data. To determine the difference between two or more sets of qualitative variables, use the chi square test (x2). The mean ± SD (standard deviation) was used to express quantitative data. Two independent groups of normally distributed variables (parametric data) were compared using the independent samples t-test. When the p-value was equal to or less than 0.05, it was deemed significant.

Results

I. Clinical Evaluation
1. Demographic Data

Twenty patients were included in this study with varying degrees of atrophic post-acne scars (10 moderate and 10 severe) classified according to Goodman & Baron's qualitative classification. The study consisted of eight males (40%) and twelve females (60%) who attended the Dermatology Outpatient clinics at Ain Shams University Hospitals, Cairo and the National Research Centre, Giza, Egypt between June 2019 and December 2019. The patients ranged in age from 18 to 55 years, with a mean age of 28.6 ± 7.34 years. It was observed that 35% of patients have positive family history of atrophic post-acne scars. The skin phototypes, according to the Fitzpatrick scale, were as follows: Type II (15%), Type III (65%), and Type IV (20%).

2. Clinical Improvement

Almost all patients showed a great improve in skin texture, tone, and a reduce in the number and depth of the scars after each treatment session. The maximum improvement was observed four weeks after the final treatment session. The combined treatment with fractional CO_2 laser and punch elevation (PE) demonstrated superior resolution compared to treatment with the fractional CO_2 laser alone (Figures 1, 2, 3).

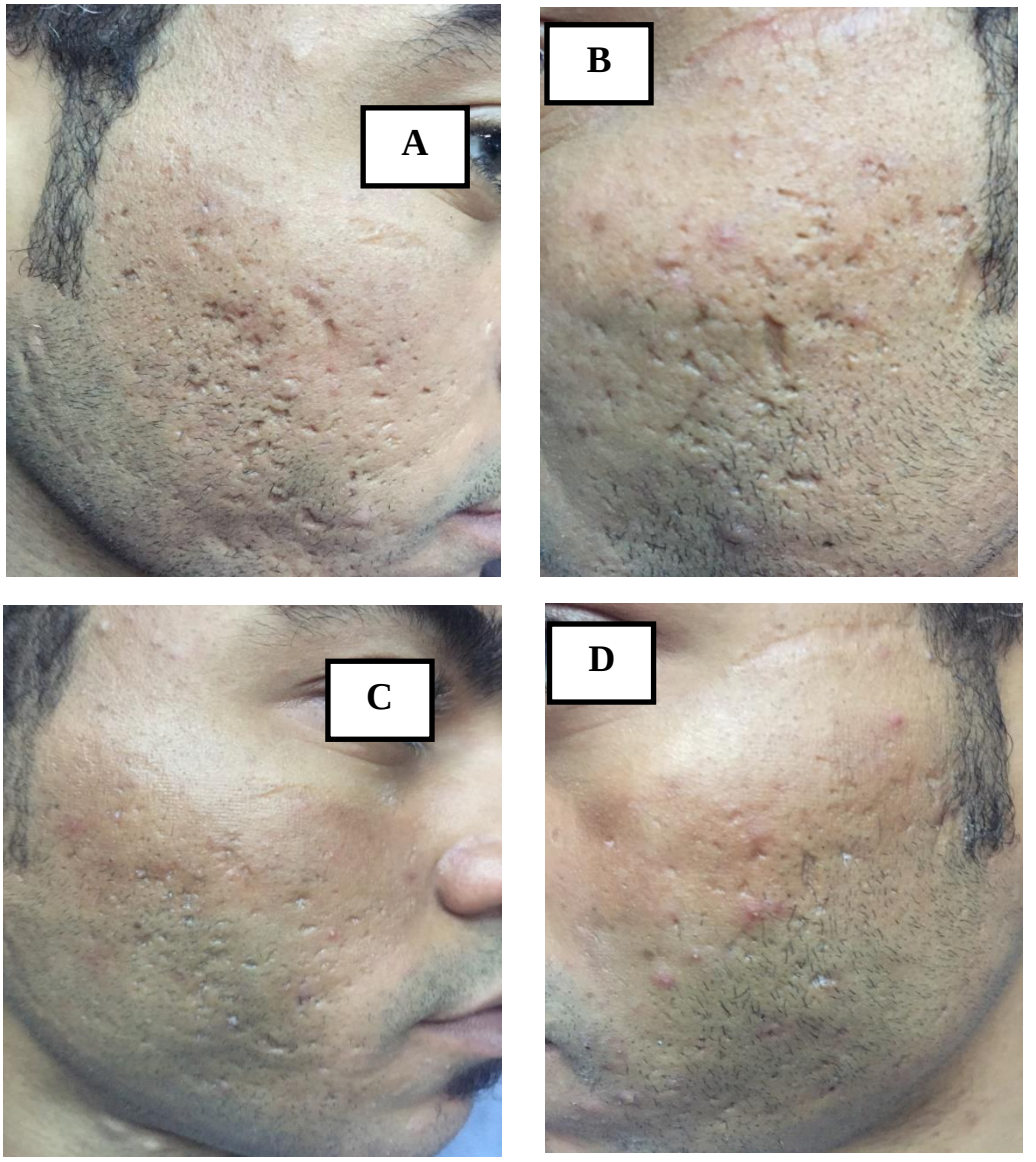

Figure (1): A 28-year-old male patient with severe acne scars mostly boxcar and icepick scars underwent punch elevation technique and two sessions of fractional CO_2 laser (one month interval). The response was very satisfactory.

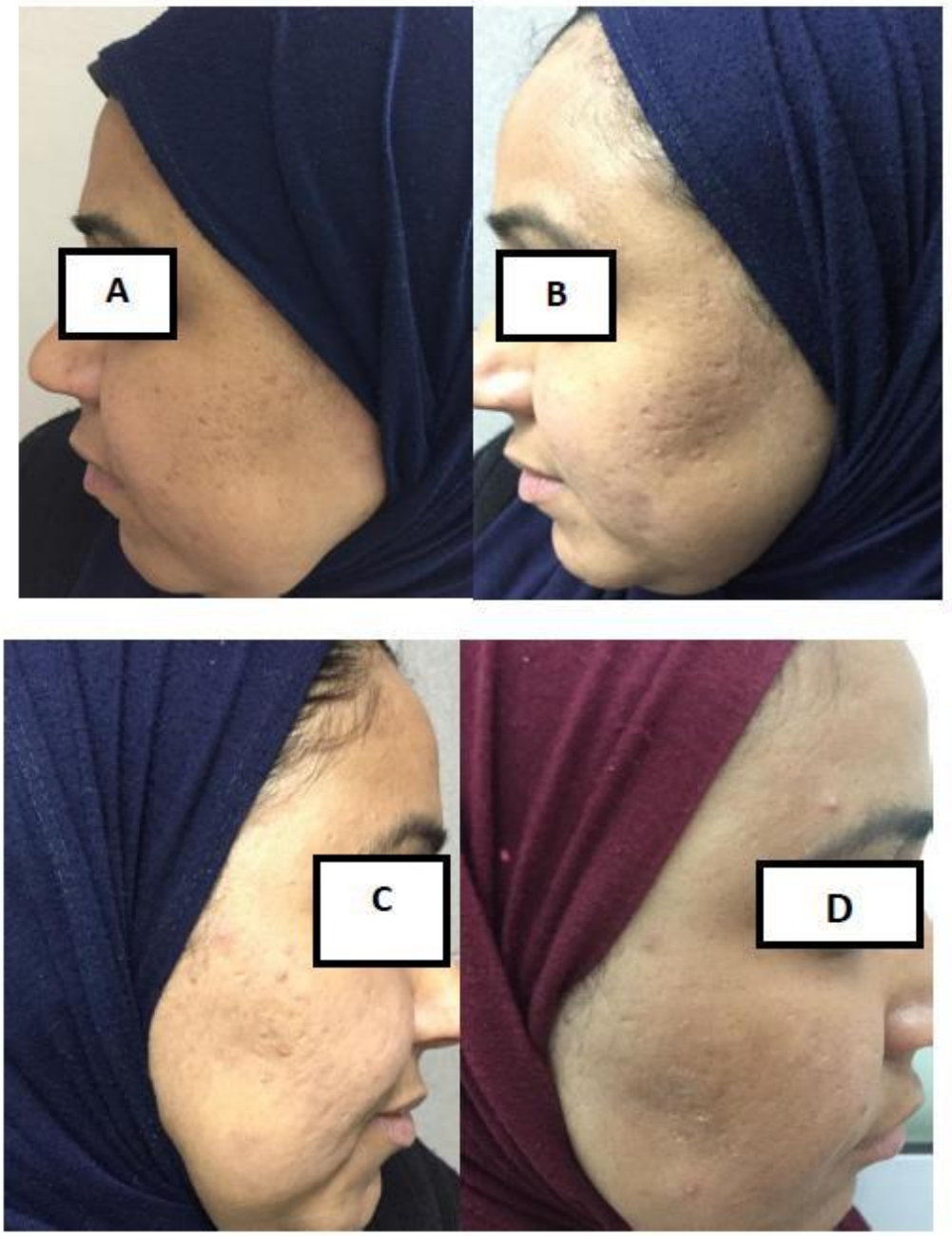

Figure (2): A 29 years old female, treated with two sessions of fractional CO_2 laser alone with the response rated as good.

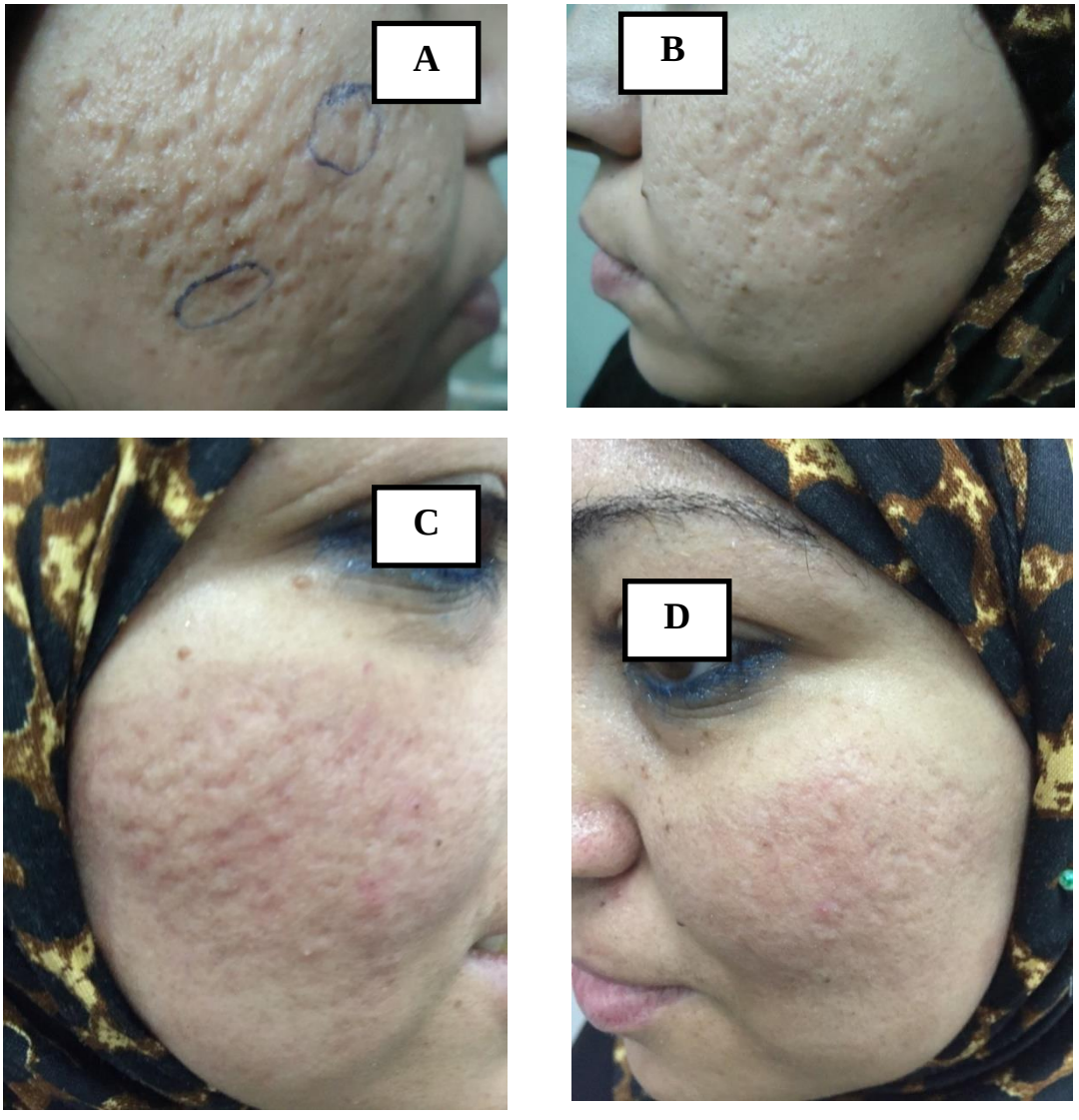

Figure (3): A 35-year-old female patient with acne scars including icepick, boxcar, and rolling scars on the face. The right side (treated with PE and fractional CO_2 laser) showed an excellent response, while the left side (treated with fractional CO_2 laser alone) showed a good response.

3. Quantitative Scar Assessment

Using Goodman's quantitative global acne scar grading scale, the combined PE and fractional CO_2 laser treatment showed a statistically significant improvement. The mean score on the treated side decreased from 12.3 ± 4.9 before treatment to 7.15 ± 3.96 after treatment. In contrast, the side treated with fractional CO_2 laser alone demonstrated a decrease from 12.1 ± 5.27 to 10.25 ± 5.25. The improvement in the combined treatment group was highly significant ($p < 0.001$).

Table (1): Improvement According to Goodman's Scale

Improvement Grade	PE + Fractional CO_2 Laser (%)	Fractional CO_2 Laser Alone (%)
Minimal	10%	80%
Moderate	70%	15%
Good	20%	5%

PE=Punch elevation

Additionally, the mean percentage of change in Goodman's scale was significantly higher with the combined treatment (44.40% ± 15.18) compared to fractional CO_2 laser alone (18.89% ± 14.26) (Table 2).

Table (2): Percentage of Change in Goodman's Scale

	Mean	±SD	Minimum	Maximum	Median	IQR	
Percent of change in Goodman after punch/fractional CO_2	44.40	15.18	15	75	45.45	35.42	50
Percent of change in Goodman after fractional CO_2	18.89	14.26	0.	60	16.67	10.26	21.1

4. Patient Satisfaction

Patients rated their satisfaction on a scale of 1 to 10, one month after the final treatment session. The mean satisfaction score was significantly higher for the side treated with the combined PE and fractional CO_2 laser (6.80 ± 1.2) compared to the side treated with fractional CO_2 laser alone (5.65 ± 1.3) ($p < 0.001$).

5. Complications and Pain

The mean pain score reported after fractional CO_2 laser sessions was 6.30 ± 0.8, whereas patients experienced minimal pain during the PE procedure due to local anesthesia. Five patients developed post-inflammatory hyperpigmentation, which resolved spontaneously, and no other complications such as secondary infection, scarring, keloid formation, or prolonged erythema were reported.

II. Histopathological Evaluation

Histopathological analysis was performed on six patients before and one month after treatment with the combined PE and fractional CO_2 laser technique **(Table 3)**

Before Treatment Results:

- Fibroblast activity (VEGF marker): 5.87 ± 1.87%
- Epidermal thickness (H&E stain): 635.65 ± 62.63 μm
- Type I collagen (Mallory trichrome stain): 45.76 ± 4.37%

- Type III collagen (Silver stain): 4.20 ± 1.64%

After Treatment Results:

- Fibroblast activity increased to 19.14 ± 4.47% ($p < 0.003$).
- Epidermal thickness increased to 1497.35 ± 61.76 µm ($p < 0.001$).
- Type I collagen decreased to 29.01 ± 4.92% ($p < 0.01$).
- Type III collagen increased to 9.86 ± 2.34% ($p < 0.02$).

Table (3): Histopathological Results Before and After Treatment

Parameters	**Before Treatment (Mean ± SD)**	**After Treatment (Mean ± SD)**
Fibroblast Activity (%)	5.87 ± 1.87	19.14 ± 4.47
Epidermal Thickness (µm)	635.65 ± 62.63	1497.35 ± 61.76
Type I Collagen (%	45.76 ± 4.37	29.01 ± 4.92
Type III Collagen (%)	4.20 ± 1.64	9.86 ± 2.34

Fibroblast Activity and Tissue Regeneration

Fibroblast activity, measured using VEGF immunohistochemistry, showed a significant increase from 5.86% to 19.13% ($P < 0.003$) one month after treatment with the combined punch elevation and fractional CO_2 laser. This increase indicates enhanced tissue regeneration (Figure 4).

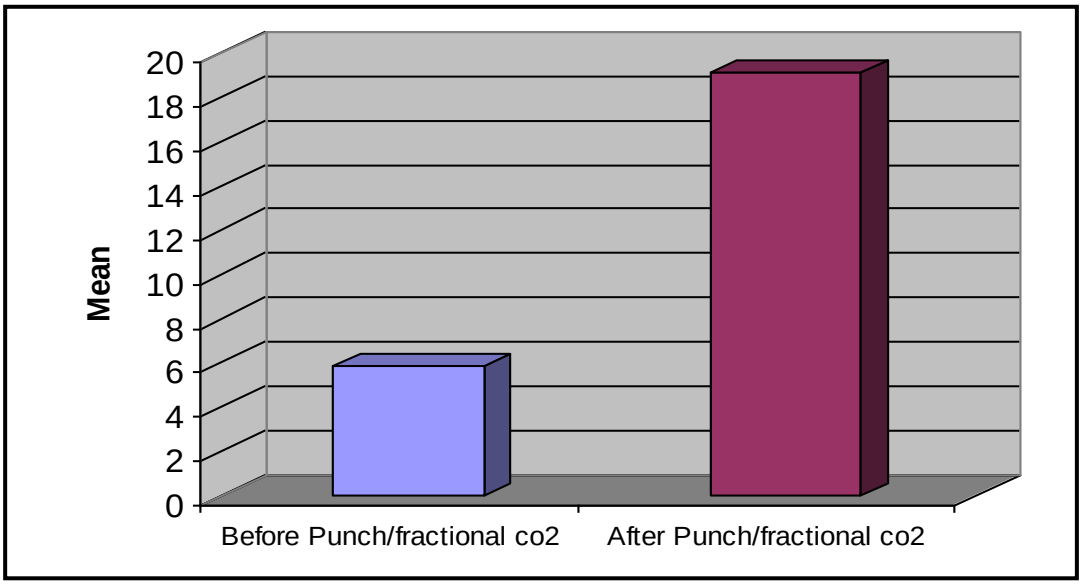

Figure (4): Comparison between fibroblast activity before and after punch elevation /fractional CO_2 laser treatment with the uses of VEGF Immunohistochemical markers

Epidermal Thickness

Epidermal thickness, assessed using H&E staining, demonstrated a significant increase from 635.64 mm to 1497.34 mm ($P < 0.001$) one month after the same treatment. This substantial increase highlights considerable tissue remodeling and regeneration (Figure 5).

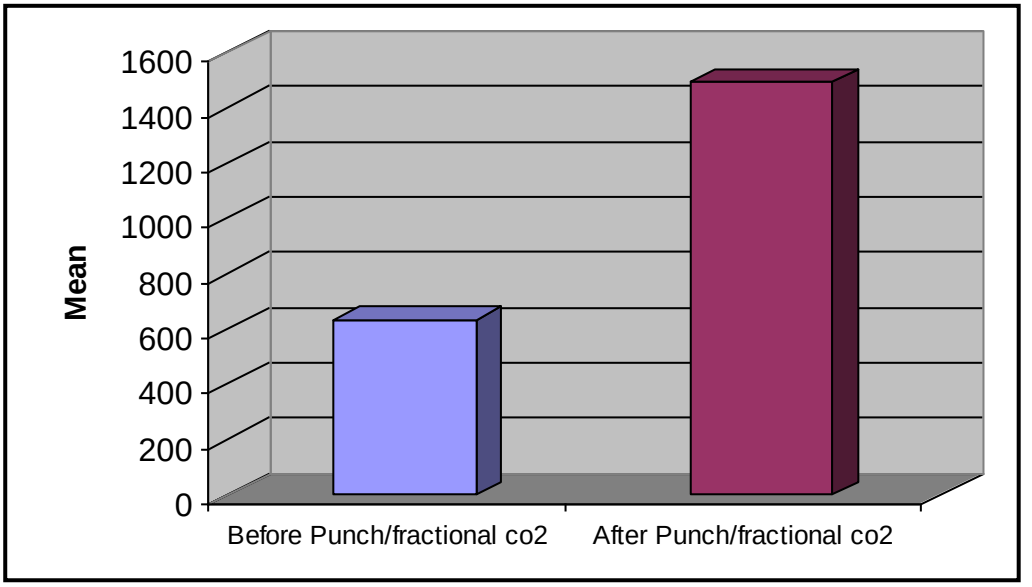

Figure (5): Comparison between epidermal thickness before and after punch elevation/fractional CO_2 laser treatment with the use of hematoxylin and eosin stains

Collagen Composition

Analysis of type I collagen content using Mallory trichrome staining revealed a significant decrease from 45.76% to 29.00% ($P < 0.01$) one month after the final fractional CO_2 laser session combined with punch elevation. This change suggests a noteworthy alteration in collagen composition following treatment (Figure 6).

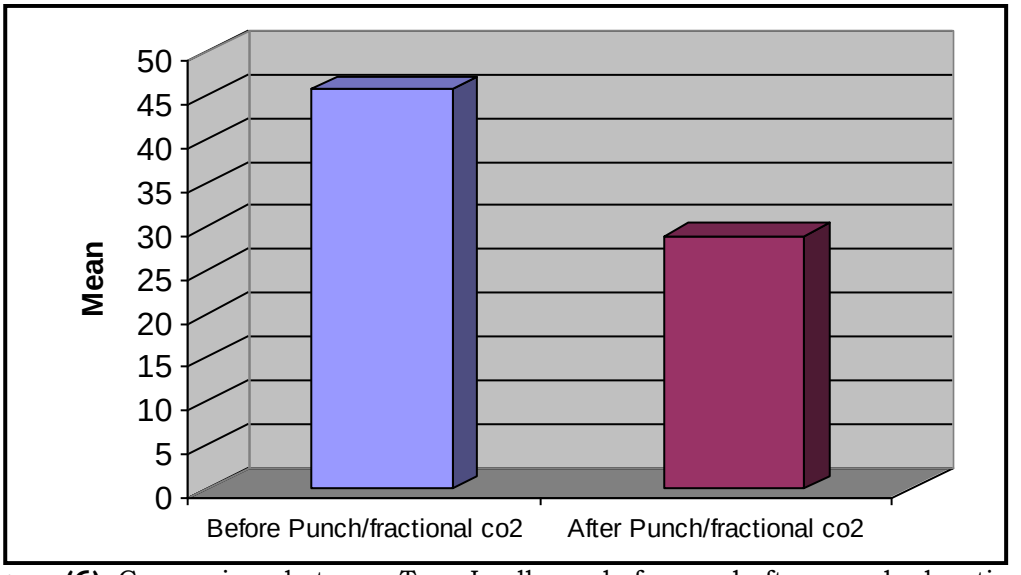

Figure (6): Comparison between Type I collagen before and after punch elevation/ fractional co2 laser treatment stained by Mallory trichrome stain

In contrast, an evaluation of type III collagen content using silver staining demonstrated a significant increase from 4.19% to 9.85% ($P < 0.02$) one month after the final fractional CO2 laser session combined with punch elevation. This increase indicates a substantial enhancement in type III collagen levels following the treatment (Figure 7).

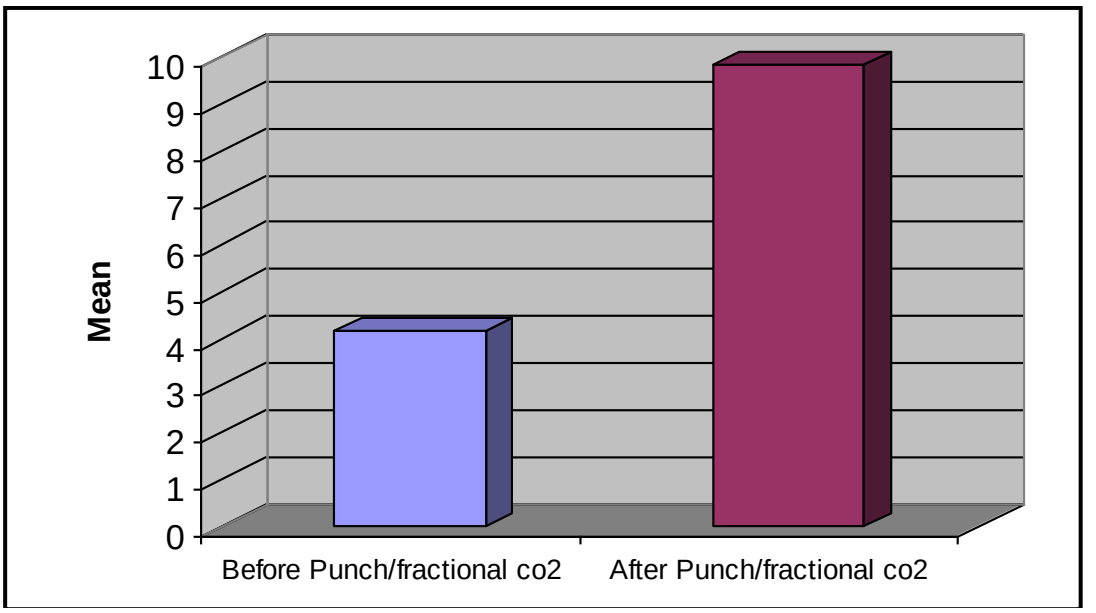

Figure (7): Comparison between Type III collagen before and after punch elevation/fractional CO_2 laser treatment stained by silver stain

Correlation Analysis

Correlation analysis revealed a significant negative correlation between the Goodman scale and fibroblast activity ($P < 0.05$), suggesting that higher scar severity is associated with lower fibroblast activity. However, no significant correlations were found between the Goodman scale and epidermal thickness, type I collagen, or type III collagen.

Correlation Between Clinical and Histopathological Findings

After treatment, no significant correlations were observed between the Goodman scale and histopathological findings for fibroblast activity, epidermal thickness, or collagen content. This suggests that the clinical improvement was not directly linked to specific histological changes post-treatment (Table 4).

Table (4): Correlations between Goodman's quantitative scale and histopathological results after treatment

		fibroblast activity after treatment	**epidermal thickness after treatment**	**Type I collagen after treatment**	**Type III collagen after treatment**
Goodman scale after treatment	R	.771	-.314	.143	-.371
	P	.072	.544	.787	.468
	Sig.	NS	NS	NS	NS

Discussion

Acne is considered a chronic inflammatory disease that primarily affects the pilosebaceous unit, leading to significant psychological distress and social stigma among those affected [11]. A common and troubling sequela of acne is scarring, which can occur easily during the course of the disease and poses one of the most challenging aspects of dermatologic practice. The heterogeneity of acne scars, which vary in structure, depth, and appearance, necessitates a nuanced understanding of treatment modalities to optimize patient outcomes [12].

Various therapeutic interventions have been developed to address acne scars, encompassing both ablative and non-ablative techniques including chemical peels, dermabrasion, punch excision, subcision, dermal fillers, and fractional photothermolysis[13]. Treatments can generally be classified into two broad categories: lifting procedures—which elevate the base of the scar closer to the normal skin surface—and resurfacing procedures, which create controlled injury to the epidermis and superficial dermis, subsequently stimulating neocollagenesis and skin repair [12].

Fractional CO2 laser resurfacing has emerged as a leading method for treating acne scars, largely due to its ability to deliver precise ablation while promoting collagen remodeling. This laser operates at a wavelength of 10,600 nm, which is highly absorbed by water, a major component of soft tissues [14]. The laser energy vaporizes tissue in a controlled manner, inducing thermal injury that stimulates a

healing response characterized by increased collagen synthesis and remodeling. However, its effectiveness is limited by its depth of penetration; typically, it effectively treats only the upper 30 μm of the skin. This limitation can be problematic for deeper scars that may necessitate multiple treatment sessions, potentially leading to further scarring and increased patient discomfort [15].

The punch elevation technique, in contrast, is particularly beneficial for addressing deep atrophic scars. This method involves excising a cylindrical portion of the scar tissue and repositioning it at the level of the surrounding skin, allowing for simultaneous resurfacing treatments. By freeing the tissue at the subcutaneous fat level or transecting it, the procedure effectively elevates the scar while maintaining the integrity of the surrounding skin. This technique has shown promise in improving the efficacy of acne scar treatments, particularly for scars characterized by defined edges and normal-appearing bases[16]. The integration of punch elevation with fractional CO_2 laser resurfacing represents a novel approach to enhance treatment outcomes by addressing the multifaceted nature of acne scarring[7].

Our study sought to compare the efficacy of fractional CO_2 laser resurfacing alone against a combined approach of fractional CO_2 laser resurfacing with punch elevation in patients with atrophic acne scars. With a cohort of 20 patients, our findings demonstrated a statistically significant improvement in scar severity, as assessed by the Goodman quantitative scale. The combined treatment group exhibited an impressive mean change of 44.40%, compared to 18.89% in the laser-only group. This significant difference underscores the potential benefits of employing a combination approach to maximize clinical efficacy.

The enhanced results of the combined treatment can be attributed to the synergistic effects of both modalities. The fractional CO_2 laser stimulates collagen production and remodeling in the dermis, which is essential for improving scar texture and depth. Concurrently, the punch elevation technique mechanically lifts the scar tissue, allowing for more effective integration and healing at the wound site. This dual mechanism of action promotes a more robust remodeling response, leading to greater aesthetic improvements [14].

Furthermore, patient satisfaction rates mirrored these findings, with mean scores of 6.8 for the combined treatment versus 5.65 for the laser-only side. The histopathological assessments provided additional evidence of the treatment's effectiveness, revealing significant increases in epidermal thickness and fibroblast activity post-treatment. The increase in epidermal thickness indicates enhanced skin barrier function and overall skin health, which can improve the appearance of scars. Higher fibroblast activity is associated with increased collagen and extracellular matrix production, vital for effective scar healing. These changes correlate with enhanced collagen remodeling and skin texture improvement, aligning with previous research suggesting that fractional CO_2 laser treatment stimulates collagen type III production, crucial for effective scar healing [17].

Limitations

Despite the encouraging results, we must acknowledge few limitations. The sample size is relatively small, which limits the generalizability of some findings, and the short follow-up duration may not fully capture the long-term effects of treatment, particularly regarding collagen remodeling, which can continue for several months post-procedure.

Future Directions

Further research should focus on larger scale, multicenter trials and thorough follow-up periods to thoroughly evaluate the long term efficacy and safety of combined treatment modalities. Investigating the integration of other techniques, such as microneedling or platelet-rich plasma (PRP) therapy alongside punch elevation and fractional CO_2 laser resurfacing, may yield synergistic effects and further improve patient outcomes. Additionally, understanding the influence of patient demographics and scar characteristics on treatment response will be essential for developing personalized approaches in managing acne scars.

Conclusion

The combined use of punch elevation and fractional CO2 laser resurfacing offers a promising strategy for the effective management of atrophic acne scars. This approach not only enhances clinical efficacy but also minimizes the need for multiple laser sessions, addressing both economic and procedural concerns associated with acne scar management. As our understanding of acne scarring evolves, continued innovation and research into combination therapies will be essential to provide effective, patient-centered solutions for this prevalent dermatological issue. Future studies are warranted to evaluate the efficacy of these treatment modalities in diverse patient populations.

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