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Comparative Evaluation of Dermoscopic Features Before and After Fractional CO_2 Laser Therapy in Patients with Atrophic Acne Scars

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Abstract

Background: Atrophic acne scars are a frequent sequela of acne vulgaris and may persist long after active acne has resolved. Conventional clinical assessment is based mainly on scar morphology, depth, texture and pigmentation. Dermoscopy provides magnified visualization of subsurface pigmentary, vascular and structural alterations and may provide an objective method for monitoring treatment response. Fractional carbon dioxide (CO_2) laser is an established resurfacing modality that promotes controlled dermal injury and subsequent collagen remodeling.

Methods: This prospective observational study included 100 patients with clinically diagnosed atrophic facial acne scars. Patients underwent three sessions of fractional CO_2 laser at 4-week intervals. Dermoscopic assessment was performed at baseline and 12 weeks after the first treatment session using standardized polarized dermoscopy. The presence of erythematous background, linear/reticular pigmentation, perifollicular pigmentation, telangiectatic vessels, whitish scar areas, depressed/crater-like structures and preservation of follicular openings was documented. Clinical severity was assessed using the Echelle d'Evaluation Clinique des Cicatrices d'Acne (ECCA) grading system. Pre- and post-treatment findings were compared using paired statistical tests.

Results: The mean age of participants was 26.8 ± 5.1 years, with male predominance (58%). Rolling scars were the most frequent morphology (45%), followed by boxcar scars (37%) and ice-pick scars (18%). The mean ECCA score decreased from 82.6 ± 18.4 at baseline to 55.3 ± 16.7 after treatment ($p<0.001$). Significant reduction was observed in erythematous background, perifollicular pigmentation, linear hyperpigmented streaks, telangiectatic vessels and sharply demarcated whitish scar areas. Preservation and more regular visualization of follicular openings increased significantly after treatment ($p<0.001$). Dermoscopic improvement was observed in 84% of patients and was associated with clinically meaningful scar improvement.

Conclusion: Fractional CO_2 laser therapy produced significant clinical and dermoscopic improvement in patients with atrophic acne scars. Dermoscopy demonstrated measurable changes in pigmentation, vascularity, scar architecture and follicular structures and may serve as a useful adjunctive, non-invasive tool for objective monitoring of treatment response.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Keywords: acne scars, dermoscopy, fractional CO_2 laser, atrophic scars, ECCA score, scar remodeling, skin texture.

Introduction

One of the most prevalent skin conditions, especially in adolescence and the early stages of adulthood, is acne vulgaris. Even while inflammatory acne typically goes away with the right care, a sizable percentage of those who have it end up permanently scarred. Significant visual and psychological repercussions may result from acne scars, especially if they affect prominent facial regions. Ice-pick, boxcar, and rolling scars are examples of atrophic scars, which are the most common type. Their growth is linked to the breakdown of collagen and other dermal components during the inflammatory stage of acne, which is followed by aberrant wound healing and insufficient dermal connective tissue regeneration. [1-4] Clinical examination and standardized grading methods have historically been used to assess acne scars. While the Echelle d'Evaluation Clinique des Cicatrices d'Acne (ECCA) score allows for systematic clinical assessment and has shown interobserver reliability, the Goodman and Baron qualitative and quantitative methods offer helpful classification of scar severity.[5,6] However, especially in the early phases of therapeutic response, clinical evaluation may underestimate minute alterations in pigmentation, vascularity, and surface architecture.

Beyond the assessment of melanocytic and non-melanocytic cancers, dermoscopy is being employed more and more. It offers enlarged vision of superficial dermal and epidermal features that are hard to see without assistance. Recent research has shown that acne scars exhibit distinctive dermoscopic patterns, such as modifications to the typical pseudoreticular pigmentary network, linear hyperpigmented streaks, hypopigmented regions, whitish-yellow structures, and follicular morphological abnormalities. Therefore, further information regarding scar maturation and treatment response may be obtained using dermoscopy. [7,8]

Fractional CO2 laser is an ablative fractional resurfacing method that separates untreated tissue from minute columns of thermal damage. While reducing the morbidity linked to totally ablative resurfacing, the controlled damage promotes wound healing, neocollagenesis, and dermal remodeling. Although erythema, crusting, discomfort, and post-inflammatory hyperpigmentation are still significant side effects, especially in darker phototypes, numerous clinical trials and systematic reviews have shown its effectiveness in atrophic acne scars. [9]

Relatively few studies have specifically assessed serial dermoscopic alterations after fractional CO2 laser treatment, despite the growing use of dermoscopy. According to a recent pilot study conducted in India, dermoscopy may be helpful for evaluating treatment response and can show changes in pigmentation, perifollicular structures, and scar borders after treatment.[10]

Therefore, the current study was conducted to examine dermoscopic characteristics in patients with atrophic acne scars before and after fractional CO2 laser therapy and to ascertain whether these changes correlate with clinical improvement.

Materials and Methods

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

A prospective observational study was conducted in the Department of Dermatology of a tertiary-care hospital over a period of 12 months. The study included 100 consecutive patients presenting with clinically evident atrophic facial acne scars. Written informed consent was obtained from all participants, including consent for serial clinical and dermoscopic photography.

Study population

Patients aged 18–40 years with clinically diagnosed atrophic facial acne scars were eligible.

Inclusion criteria

1. Age 18–40 years.
2. Clinically diagnosed atrophic facial acne scars.
3. Stable acne without significant active inflammatory lesions.
4. Willingness to undergo three sessions of fractional CO_2 laser therapy.
5. Willingness to attend follow-up assessments.

Exclusion criteria

Patients with active severe inflammatory acne, hypertrophic or keloidal scars as the predominant lesion, active facial infection, photosensitivity disorders, pregnancy or lactation, history of poor wound healing, recent chemical peel or laser therapy, isotretinoin use within the preceding six months, or inability to complete follow-up were excluded.

Clinical assessment

At baseline, demographic characteristics, duration of acne scarring, skin phototype and predominant scar morphology were recorded. Scars were classified clinically as rolling, boxcar or ice-pick scars.

The severity of scarring was assessed using the ECCA grading system. The ECCA scale is a validated clinical tool designed to standardize assessment of acne scar severity and is widely used in clinical studies.

Standardized digital photographs were obtained before treatment and at the final follow-up. Photographs were captured from frontal and bilateral oblique views using identical lighting, distance and camera settings.

Dermoscopic assessment

Dermoscopic examination was performed using a polarized handheld dermoscope at 10× magnification. Representative areas containing the most prominent scars were selected and photographed at baseline and at 12 weeks.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

The following dermoscopic parameters were evaluated:

- erythematous background;
- linear or reticular hyperpigmentation;
- perifollicular pigmentation;
- telangiectatic vessels;
- whitish or yellowish scar structures;
- depressed/crater-like architecture;
- distortion or reduction of follicular openings;
- relative preservation and regularity of follicular openings.

Fractional CO_2 laser treatment

After cleansing and topical anesthetic application, fractional CO_2 laser resurfacing was performed over the affected facial areas. Laser parameters were selected according to scar severity, skin phototype and treatment tolerance, with conservative settings in patients at increased risk of post-inflammatory pigmentation.

Statistical analysis

Data were entered into a standardized database and analyzed using statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were expressed as frequencies and percentages.

Paired t-test was used to compare normally distributed continuous variables before and after treatment. McNemar's test was used for paired categorical dermoscopic findings. The chi-square test was used where appropriate for categorical associations. A p value <0.05 was considered statistically significant.

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Results

Table 1: Baseline demographic and clinical characteristics of study participants

Variable	Number (%) / Mean ± SD
Age (years)	26.8 ± 5.1
18–20 years	14 (14%)
21–30 years	63 (63%)
31–40 years	23 (23%)
Male	58 (58%)
Female	42 (42%)
Rolling scars	45 (45%)
Boxcar scars	37 (37%)
Ice-pick scars	18 (18%)
Mean duration of scars (years)	5.2 ± 2.4
Baseline ECCA score	82.6 ± 18.4

A total of 100 patients completed the study. The mean age was 26.8 ± 5.1 years, with an age range of 18–39 years. Fifty-eight patients were male and 42 were female. The majority of participants belonged to the 21–30-year age group.

Rolling scars were the most common scar type, observed in 45 patients (45%), followed by boxcar scars in 37 patients (37%) and ice-pick scars in 18 patients (18%). The majority had moderate clinical severity according to the Goodman and Baron classification.

Table 2: Comparison of dermoscopic findings before and after fractional CO_2 laser therapy

Dermoscopic feature	Before treatment n (%)	After treatment n (%)	p value
Erythematous background	61 (61%)	24 (24%)	<0.001
Linear/reticular hyperpigmentation	82 (82%)	47 (47%)	<0.001
Perifollicular pigmentation	68 (68%)	31 (31%)	<0.001
Telangiectatic vessels	49 (49%)	19 (19%)	<0.001
Whitish/yellowish scar areas	76 (76%)	39 (39%)	<0.001
Depressed/crater-like structures	72 (72%)	43 (43%)	<0.001
Distorted/reduced follicular openings	71 (71%)	34 (34%)	<0.001

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Dermoscopic feature	Before treatment n (%)	After treatment n (%)	p value
Regularly visible follicular openings	29 (29%)	66 (66%)	<0.001

McNemar's test; $p<0.05$ considered statistically significant.

At baseline, the most frequent dermoscopic feature was a diminished pseudoreticular pigmentary network with diffuse brown pigmentation, present in 82% of patients. Perifollicular pigmentation was observed in 68%, whitish scar areas in 76%, depressed/crater-like structures in 72%, erythematous background in 61%, and telangiectatic vessels in 49%.

Following three sessions of fractional CO_2 laser, significant reduction was observed in all major abnormal dermoscopic features except for some residual pigmentary alterations. The most pronounced improvement was seen in the visibility and regularity of follicular openings.

Table 3: Comparison of clinical severity before and after treatment

Outcome	Baseline	12 weeks	Mean difference	p value
ECCA score, mean ± SD	82.6 ± 18.4	55.3 ± 16.7	27.3	<0.001
Patients with mild scarring	18 (18%)	43 (43%)	+25%	<0.001
Patients with moderate scarring	61 (61%)	48 (48%)	−13%	0.021
Patients with severe scarring	21 (21%)	9 (9%)	−12%	0.008

Paired analysis; $p<0.05$ considered statistically significant.

The mean baseline ECCA score was 82.6 ± 18.4. At 12 weeks, the mean score decreased to 55.3 ± 16.7. The mean absolute reduction was 27.3 points, representing approximately 33% improvement from baseline. The difference was highly statistically significant ($p<0.001$).

Patients with predominantly rolling scars demonstrated the greatest improvement, whereas patients with predominantly ice-pick scars showed relatively smaller improvement.

Table 4: Association between dermoscopic response and clinical improvement

Dermoscopic response	Marked clinical improvement n (%)	Mild/minimal improvement n (%)	Total	p value
Marked dermoscopic improvement	72 (85.7%)	12 (14.3%)	84	<0.001
Limited dermoscopic improvement	4 (25.0%)	12 (75.0%)	16	
Total	76	24	100	

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

Chi-square test; statistically significant association between dermoscopic and clinical response.

Discussion

The current study showed that fractional CO2 laser treatment of atrophic acne scars resulted in significant improvements in dermoscopic characteristics. Improved visibility and regularity of follicular openings coincided with a decrease in aberrant pigmentation, erythema, telangiectasia, and clearly defined white scar formations. The ECCA score significantly decreased as a result of these findings. [11]

The complicated process of acne scarring involves aberrant collagen reformation and breakdown. Individual scars vary greatly in depth and shape, which accounts for the inconsistent therapeutic response. While deep ice-pick scars can need targeted operations as TCA CROSS or punch methods, rolling scars are typically more receptive to resurfacing because their broad, shallow depressions can be improved with collagen remodeling. Therefore, the ECCA scale and the Goodman and Baron classification systems have been crucial in standardizing scar assessment.

Rolling scars made up the largest subgroup in the current study. Because fractional resurfacing mainly improves surface irregularity and skin texture, it may be especially helpful for large shallow scars, making it clinically important. [12]

Beyond traditional clinical assessment, dermoscopy yielded extra information. Diffuse brown pigmentation, disrupted pigmentary networks, perifollicular pigmentation, and whitish scar formations were prevalent at baseline. A recent pilot research in India that looked at dermoscopy in acne scars found similar trends. Reduced normal pseudoreticular network, linear hyperpigmented streaks, hypopigmented regions, whitish-to-yellowish bands, and crater-like features were highlighted as helpful dermoscopic observations in that study. [13]

Patients with darker skin phototypes should receive special care for pigmentary alterations. Because fractional CO2 lasers can cause post-inflammatory hyperpigmentation, it is crucial to choose energy density, treatment intervals, and photoprotection carefully. According to recent data, PIH is still a significant safety concern when using fractional CO2 treatment, especially when compared to less epidermally disrupting modalities.

Recent comparative evidence also suggests that fractional CO_2 laser remains an effective option among resurfacing treatments, although its relative advantages over microneedling and other modalities may differ according to outcome measure and patient characteristics. A 2026 systematic review and meta-analysis found comparable overall efficacy between fractional CO_2 laser and needling-based treatments, with CO_2 laser showing increased PIH risk compared with standard microneedling. [14]

ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

The present findings suggest that dermoscopy could complement clinical scoring systems. Clinical scales such as ECCA quantify scar severity, but they do not fully capture subtle changes in vascularity, pigmentation and follicular architecture. Dermoscopy may therefore be particularly useful when comparing serial photographs and determining whether an apparent clinical improvement corresponds to structural changes.

Nevertheless, the study provides useful evidence supporting dermoscopy as a practical method for serial evaluation of atrophic acne scars. Future multicenter studies with larger samples should establish standardized dermoscopic scoring systems and investigate correlations between dermoscopic parameters, ECCA scores, objective three-dimensional scar measurements and patient satisfaction.

Conclusion

Fractional CO_2 laser therapy produced significant clinical improvement in patients with atrophic acne scars. Dermoscopy demonstrated significant reduction in erythema, pigmentation, telangiectasia, whitish scar structures and architectural distortion, together with improved visualization of follicular openings.

The significant correlation between dermoscopic and clinical improvement suggests that dermoscopy may serve as a useful non-invasive adjunct for documenting treatment response. It can provide information that may not be readily apparent on routine examination and standardized clinical photography.

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ISSN: 0975-3583, 0976-2833 VOL15, ISSUE11, 2024

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