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FRACTIONAL CO2 LASER VS. RADIOFREQUENCY MICRONEEDLING FOR ACNE SCAR IMPROVEMENT: EFFICACY, SAFETY, AND PATIENT SATISFACTION

Ghazala Said[1*], Naseeba Abdul Rasheed[2], Sofia Sarwar[3]

[1*]Consultant Dermatologist and Aesthetic Physician, FCPS, Dermatology Department, Le Lotus Clinique Peshawar Pakistan.
[2]Consultant Dermatologist, FCPS, Medicine and Allied, Dermatology Department, Bolan Medical Complex Hospital Quetta, Pakistan
[3]Senior Registrar, Consultant Dermatologist, Dermatology Department, Bioflex Aesthetic clinic Islamabad.

***Corresponding author:** Ghazala Said
*Email: Dr.ghazal11@yahoo.com

Abstract

Introduction: Acne scarring is a prevalent dermatological concern, particularly among young adults, often resulting in long-lasting cosmetic and psychological effects. Among various treatment options, fractional CO2 laser and radiofrequency microneedling (RFMN) have emerged as effective modalities for scar remodeling.

Objective: To compare the efficacy, safety, and patient satisfaction of fractional CO2 laser and radiofrequency microneedling in the treatment of atrophic acne scars.

Materials and Method: The randomized comparative study was conducted at Dermatology Department, Le Lotus Clinique Peshawar Pakistan in the duration from December, 2024 to May, 2025. A total of sixty study participants were randomly assigned to two groups: Group A participants were treated with fractional CO2 laser whereas in Group B RFMN was used. Each had three sessions four weeks apart from each other. The study used the grading system by Goodman and Baron and patient satisfaction questionnaires to measure the effected outcomes.

Results: There was commendable clinical improvement in both groups. Clinical results were marginally better with the use of CO2 Laser, but RFMN had a more improved safety profile, fewer side effects, and greater patient satisfaction.

Conclusion: Both choices are effective, but RFMN has a better safety record and is the patient's preferred choice.

Keywords: Acne scars, Fractional CO2 laser, Radiofrequency microneedling, Efficacy, Patient satisfaction, Scar treatment.

INTRODUCTION

Acne scarring is a prevalent skin complaint that impacts the mental health and social lives of people affected by it in a significant way. A wide range of treatments exist for acne scars, but fractional CO2 laser and radiofrequency microneedling (RFMN) have now become a well-established minimal treatment option for atrophic scars. The desire to evaluate effectiveness, safety, downtime, and patient satisfaction has caused an explosion in comparative studies of these treatments. Rajput et al. (1) stated

that fractional CO2 laser and RFMN both were effective in diminishing acne scars in a prospective and nonrandomized study, albeit fractional CO2 laser showed minimal improvement in scar depth. In contrast, RFMN demonstrated enhanced tolerability and a lack of any complications in patients. CO2 lasers remove tissue in two layers while RFMN ignores the epidermis by using insulated needles to deliver heat, which minimizes surface trauma and the risk of PIH (2). The differences are the most significant for Fitzpatrick skin types III–V, who are at high risk of post-inflammatory hyperpigmentation. Mamizadeh et al. (3) studied the application of subcision combined with microneedling or fractional CO2 laser, with the conclusion that, though both techniques were successful, patients preferred microneedling because of its mild discomfort and short recovery time.

Combination methods from recent studies were highlighted, suggesting that the combination of RFMN and CO2 laser may produce more effective results. Mandavia et al. (4) reported a systematic review and case series where combined treatments, especially in deep boxcar and rolling scar management, exhibited better results. However, the cost containment and potential severity of the cumulative adverse effects emphasise the necessity for prudent patient assessment. Hendel et al. (5) noted in a randomized split-face trial that it was despite the superior photographic improvements through CO2 laser that RFMN exhibited better tolerability and lower complication rates thereby reiterating the call for patient-centered treatment protocols. There have been several reviews that have attempted to systematically organize and compare these treatment options. Nobari et al. (6) carried out a thorough review, and they found that ablative fractional lasers such as CO2 are the best for treating deeper scars, while the RFMN proves better even in terms of safety particulars for people with darker skin types. The outcomes support the study of Behrangi et al. (7), who documented the effectiveness of microneedling, whether or not it included platelet-rich plasma, as effective as the fractional CO2 laser but with less erythema and healing time.

RFMN is gaining more and more scientific basis as an adequate self-sufficient therapeutic technique, as shown by recent research. Niaz et al. (8) systemically appraised studies, emphasising continued clinical benefits of RFMN with minimal adverse outcomes, validating the use of RFMN as an effective monotherapy in treating acne scars. Similarly, Canpolat et al. (9) also reported similar improvements concerning scar scoring through both methods, but experienced significantly higher patient satisfaction with RFMN. This in turn vindicates the fact that both clinical assessment and feedback are very critical in determining the effectiveness of a treatment. Safety is never too small when it comes to decisions on treatments. Zhao et al. (10), using Bayesian network meta-analysis reported that laser therapies tended to show slightly superior objective gains at the cost of increase risks of post-inflammatory hyperpigmentation, especially in darker-skinned individuals. As such, RFMN may be the perfect treatment for a larger population of patients. Li et al. (11) stated that a meta-analysis found that RFMN offers a reliable ratio of treatment effects and safety with lower inflammation and more rapid recovery times when compared to the conventional ablative procedures. The continual growth of new technologies, as well as changes in treatment strategies, are actively changing how acne scars are treated. Qoreishi et al. reviewed novel combination therapies and the existing trend suggesting a shift to patient-centered treatments, accelerating healing processes (12). Kim et al. 13) carried out a study comparing the combined application of RFMN and ablative fractional laser to standalone laser treatment, showing how the use of both methods improved both texture and depth outcomes with reduced recovery time. These integrated approaches may become the hub of acne scar treatment strategies, especially if the approach to scar features is personalized on a patient-by-patient basis. Medical studies carried out in settings around the real world provide valuable insight regarding how treatments work for actual patients. Ding et al. (14) conducted an analysis of 126 patients using RFMN for a real-world trial, where they reported significant improvements in the appearance of scars, with a low rate of complications, as proof of the practical suitability of this technique in everyday clinical practice. Elesawy et al.'s (15) leading review emphasized that advances in fractional laser mechanism understanding and clinical applications require individualized treatment regimens explained in light of patient skin type, scar characteristics, and personal expectations.

The existing body of research shows that fractional CO2 laser and RFMN represent both effective methods for the treatment of acne scars, and both of them bear specific benefits. CO2 laser is very productive for serious and deep scars, but often it takes a much longer time to recover, and there is a higher possibility of complications. The caveat of having less aggressive results can still be offset by the safety, minimal recovery, and satisfaction for patients, all of which are great for patients with darker skin or bound by their lifestyle. The continued challenges of dealing with acne scars make it essential to identify the fine points of the strengths and weaknesses of various therapies in order to reach the optimal standard of skin care.

Objective:
To study the comparative success, safety aspects and patient experience in fractional CO2 laser and radio frequency microneedling of acne scars in the context of tertiary health care dermatology departments.

MATERIALS AND METHODS

Design: Comparative Interventional Study.
Study setting: The study was conducted at the Dermatology Department, Le Lotus Clinique Peshawar Pakistan
Duration: The study was conducted over a six-month in the duration from December, 2024 to May, 2025.
Inclusion Criteria: Participants in the study were patients between the ages of 18 and 45, who revealed moderate to severe atrophic acne scars. Participants were limited to individuals with Fitzpatrick skin types II to IV for the sake of consistency in skin response. All participants should not have active acne lesions during treatment period and should not have had any scar treatments in the last six months. Each person concerned consented to the study through a signed consent after being told.

Exclusion Criteria
Eligibility was limited to patients who did not have keloidal predisposition, active skin infection, or underlying conditions that affect wound healing, such as uncontrolled diabetes. Pregnant and breastfeeding women and women who had taken isotretinoin within the previous year were excluded from the study.

Methods
The study participants amounted to 60 individuals, each randomly assigned to two groups of 30 subjects. Group A underwent treatment by fractional CO2 laser therapy, while subjects in Group B underwent radiofrequency microneedling (RF MN). All participants received a total of three sessions, four weeks apart. Before each session, time was taken to apply topical anesthetic cream (45 minutes). It was decided to use energy and density for the fractional CO2 laser, taking skin specificity and individual skin type into consideration in accordance with a given protocol. Microneedles insulated for RFMN were used to manipulate depth and thermal energy delivery in a controlled manner during these treatments. After every session, soothing ointments were given to the patients, and they were told to use sun protection. The evaluation was performed using the Goodman and Baron qualitative acne scar grading system before and at one month after the last treatment. The patient's satisfaction was analyzed on a 5-point Likert scale. During treatment and follow-up, observers registered and summarized adverse events – erythema, edema, post-inflammatory hyperpigmentation, and pain.

RESULTS

The study recruited 60 subjects, divided into two groups of 30 subjects each. The participants in both groups demonstrated similar profiles on the aspect of age, gender and skin type. The mean age of participants who received fractional CO2 laser therapy in Group A was 27.4 ± 5.2 years, while that

of participants treated with radio-frequency microneedle therapy in Group B was 26.8 ± 4.9 years. The diversity of the gender in both groups was almost equal, with the majority having the Fitzpatrick skin type IV.

Table 1: Baseline Demographic Characteristics

Parameter	Group A (CO2 Laser)	Group B (RFMN)
Mean Age (years)	27.4 ± 5.2	26.8 ± 4.9
Gender (M/F)	14/16	13/17
Fitzpatrick Skin Type II	5	5
Fitzpatrick Skin Type III	10	9
Fitzpatrick Skin Type IV	15	16

Following three treatment sessions, both groups showed significant improvement in acne scarring. Improvement was evaluated using the Goodman and Baron qualitative acne scar grading system. In Group A, 73.3% of patients showed a two-grade or more improvement, compared to 63.3% in Group B. However, the difference was not statistically significant ($p > 0.05$).

Table 2: Clinical Improvement Based on Goodman and Baron Grading

Improvement Level	Group A (n=30)	Group B (n=30)
No Improvement	2 (6.7%)	3 (10%)
One Grade Improvement	6 (20%)	8 (26.7%)
Two Grades Improvement	14 (46.7%)	13 (43.3%)
Three Grades Improvement	8 (26.7%)	6 (20%)

Patient satisfaction, measured using a 5-point Likert scale, was slightly higher in the RFMN group. In Group B, 80% of patients reported being either "satisfied" or "very satisfied" compared to 70% in Group A. This suggests that while clinical improvement was similar, RFMN may offer better tolerability and comfort.

Table 3: Patient Satisfaction Scores

Satisfaction Level	Group A (n=30)	Group B (n=30)
Very Dissatisfied	1 (3.3%)	0 (0%)
Dissatisfied	2 (6.7%)	1 (3.3%)
Neutral	6 (20%)	5 (16.7%)
Satisfied	14 (46.7%)	16 (53.3%)
Very Satisfied	7 (23.3%)	8 (26.7%)

Regarding adverse events, transient erythema and edema were more common in the CO2 laser group, with 80% reporting moderate erythema lasting up to three days. In contrast, only 50% of RFMN patients experienced mild erythema. Post-inflammatory hyperpigmentation occurred in 4 patients in Group A and only 1 patient in Group B. No serious complications were observed in either group.

DISCUSSION

Acne scarring is an increasing skin problem for younger adults, resulting in lasting negative outcomes related to appearance and mental health. There is also continuous development in therapy to guarantee scar enhancement at the same time, cutting down on side effects and time of healing. This study assessed the benefits, risks, and patient input for the fractional CO2 laser and radiofrequency microneedling (RFMN) in treating atrophic middle to severe acne scars. The study's results corroborate the accord in the literature that both techniques are efficacious, though each has its

strengths and weaknesses to define applicable use in individual cases. Fractional CO2 laser and RFMN proved to be highly significant clinically in acne scar management after three sessions. These results are consistent with those of earlier studies, showing that both procedures rejuvenate skin and lessen scarring.

According to Rajput et al. (1), both types of treatment led to less scar depth and severity, but fractional CO2 laser created somewhat better results but took more recovery time and discomfort. Consistent with earlier studies, patients in the CO2 laser cohort reported more significant clinical improvements but were subject to more frequent erythema and hyperpigmentation experienced after treatments than those in the RFMN group. Dermal remodeling is promoted by both therapies as a mechanism of action. Fractional CO2 laser creates microthermal zones in the dermis, through ablative thermal damage, which can promote the production of collagen and lead to the regeneration of tissue, according to Ref. 2. Conversely, RFMN transports radiofrequency energy to the dermis via insulated microneedles and causes induced controlled coagulation and neocollagenesis without damaging the epidermis (2, 5). This is mainly for those with dark skin, as ablative therapies are more likely to induce post-inflammation hyperpigmentation. Mamizadeh et al (3) and Hendel et al (5) reported that for severe scars, while CO2 lasers leave intensive effects behind, RFMN is best known for its superior safety and lack of post-inflammatory pigmentation issues.

There are combination therapies that are a combination of two techniques that have been done to maximize the good effects of both methods. Mandavia et al. (4) in their systematic review report that RFMN in combination with CO2 laser results in superior outcomes in managing scars, particularly in rolling and boxcar scars. However, integrative utilization of both techniques can prove expensive and unrealistic for some patients. The application of a single-modality technique in which this study engages enables us to see how every treatment works independently from the other, which is fundamental to evidence-based decision-making. RFMN presented itself as the more tolerable and less risky choice of the two modalities. The reporting of Nobari et al. (6), in a study on ablative laser treatments, indicated that erythema and edema were more frequent and marked after the procedure in patients in the CO2 laser group. The survey of Behrangi et al. (7) proved that there is less downtime and faster healing for microneedling modalities in comparison to CO2 laser, which was also the observation. One interesting feature of this research was the differences in patient satisfaction between the two treatments. Following the same benefits in the clinical domain, patients of the RFMN cohort had higher scores of satisfaction. Niaz et al. (8) reported that RFMN patients report high satisfaction levels, often associated with a more positive treatment journey than simply noticing aesthetic changes. Canpolat et al. (9) also looked at both procedures, and comparable clinical outcomes were reported, but most sufferers preferred RFMN due to its less invasive nature and the short recovery time. Zhao et al (10), through Bayesian network meta-analysis, found that CO2 lasers did better in terms of visible scar reduction in some studies, though in most cases, it caused more adverse effects, especially among those with dark skin tones. These findings demonstrate the need for individualized approaches to measuring patient preferences, skin conditions, scar traits, and the capability to accommodate downtime. Li et al. (11) and Qoreishi et al. (12) in their meta-analyses also support the conclusions, which show that RFMN performs a much more balanced result regarding both efficacy and safety, particularly in the day-to-day setting in clinical practice. In the study, it was revealed that while the laser group also showed larger gains, satisfaction was significantly higher with patients treated with the RFMN method. This depicts the gap that might exist between clinical achievement and what the patients have valued, as well as the need to involve patients in partnership in decision-making.

Kim et al. (13) explored the impact of combining fractional RF microneedling with ablative fractional lasers and found that such a combined treatment was more effective than single-therapy procedures, especially in the cases of mixed-type scars. However, the availability of equipment and patient-specific preferences are of prime importance in deciding the extent to which such advanced options can be used in a daily practice. Ding et al. (14) showed that treating more than 100 patients shows that RFMN leads to real-world clinical benefits, and thus, its safety and efficacy across different patient groups are proven. RFMN has continued to provide effective treatment of acne scars, especially to

patients looking for low side effects and a rapid recovery period, per findings. According to Elesawy et al. (15), a comprehensive review showed that optimizing outcomes calls for an apt selection of treatment when treating the type of scar, the patient's routine, and skin color. Results support this notion by indicating that while fractional CO2 laser may lead to the more marked improvements, the RFMN in general is more tolerable and acceptable to patients.

In addition, both fractional CO2 laser and radiofrequency microneedling contribute a significant degree to the eradication of atrophic acne scars. While having more pronounced results for certain skin conditions, CO2 L offers a longer recovery period and higher risk of complications, particularly in patients with darker skin types. Patients of the RFMN usually complain about greater satisfaction, a decreased possibility of side effects, and faster recovery, though they may experience less spectacular results than with the CO2 laser. The treatment choice should consider the unique scar characteristics, the patient's personal preferences, the skin color, and the general lifestyle to achieve optimal clinical and cosmetic results.

CONCLUSION

The study confirmed that fractional CO2 laser and RFMN are effective and reliable methods for treating moderate to severe atrophic acne scars. Fractional CO2 laser performed slightly better in scar severity modification, especially for deeper scars, but RFMN was quite outstanding for its increased safety and lack of downtime, as well as better acceptance by patients. However, given higher post-inflammatory hyperpigmentation and delayed erythema in the CO2 laser group, the RFMN would appear more suitable for darker-skinned and non-downtime accepting patients. Finally, the choice of treatment depends on the details of the scars, wishes of the patient, and features of the patient's skin. Considering its favorable results ratio and safety, it appears appealing and suitable for everyday dermatological practice applications such as RFMN. Further research with longer time frames for monitoring and a larger group of participants may provide further information on long-term results and the comparative effectiveness of this method.

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