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Comparative Clinical Evaluation Of Radiofrequency Micro Needling Versus Conventional Micro Needling In The Treatment Of Acne Scars In Fitzpatrick Skin Type III–IV

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Abstract

Background: Atrophic acne scarring is a well-known sequel of inflammatory acne vulgaris, and is associated with a significant psychosocial burden. There is an increased risk for post-inflammatory hyperpigmentation (PIH) in Fitzpatrick III–IV.

Objective: To compare the clinical efficacy, patient-reported outcomes and safety of RFMN and CMN in patients with atrophic acne scars of Fitzpatrick III-IV.

Methods: A prospective comparative interventional study enrolled 22 patients (G&B Grade 2–4; Fitzpatrick III–IV) into RFMN (n=11) and CMN (n=11) groups, each receiving three sessions at two-week intervals. Primary outcome was G&B scar grade change; secondary outcomes included VAS scores and patient satisfaction. Statistical methods included chi-square, t-tests, Mann–Whitney U, ANOVA, regression models, and effect sizes.

Results: Baseline characteristics were comparable between groups (all $p>0.09$). G&B improvement: RFMN 1.41±0.34 (50.0%) vs CMN 0.77±0.11 (25.7%); $p<0.001$, $d=2.735$. Clinical response: 54.5% of RFMN vs 0.0% of CMN achieved "Good" response ($p=0.004$, $V=0.710$). Mean VAS: 7.36±1.21 vs 4.55±1.29, $p<0.001$, $d=2.254$. PIH: 18.2% vs 45.5% ($p=0.361$). Treatment group was the dominant predictor of improvement ($R^2=0.853$). No serious adverse events occurred.

Conclusion: RFMN demonstrated significantly superior efficacy over CMN for atrophic acne scar management in Fitzpatrick III–IV patients, with very large effect

sizes and more favorable categorical response distributions. Both modalities were safe, with numerically lower PIH with RFMN. Adequately powered RCTs with extended follow-up are warranted.

Introduction

Acne vulgaris refers to a long-term inflammatory disease of pilosebaceous unit and is also known to be one of the most common dermatological conditions in the world. It is usually prevalent among adolescents and young adults and its prevalence rates are reported to reach up to 80-90 percent at the adolescent stage, but it can continue or even become apparent in adulthood (1).

Even though acne is viewed as a self-limiting disease, its long-term consequences, especially acnes scarring, pose a significant clinical and psychosocial cost. The scars resulting to acne may permanently disfigure, and result in low self-esteem, avoiding social interactions, anxiety, and depression mostly among the young people (2).

Acne has a complex pathogenesis, which is characterized by hyperplasia of sebum, hyper keratinization of follicles, colonization of Cutibacterium acnes, and inflammation. The inflammatory lesions in acne propagated into the deepest layer of the dermis interfere with the normal wound-healing process and lead to the abnormal collagen degradation, abnormal collagen remodelling. The inflammation can result in permanent scarring especially when the inflammation is long term or when it is not effectively managed (3).

There are three types of acne scars that include atrophic, hypertrophic as well as keloidal scars. The most common type of scars are the atrophic scars which constitute about 80-90 percent of the acne scars. They are also classified as ice pick, boxcar and rolling scars depending on the morphology and depth (4).

Ice-picks are fine and deep, boxcar scars are sharp with irregular depths, and rolling scars are broad and wave like due to dermal tethering. The extent of scarring is dependent on a number of factors such as genetic predisposition, the severity of acne, the time of inflammation, and the type of skin (5).

Fitzpatrick skin phototype is a universally recognized system of skin classification which is used to classify skin in terms of its reaction to ultraviolet radiation. The people with Fitzpatrick III-IV skin types possess moderate to high quantities of melanin and are more susceptible to pigmentary changes after inflammatory or surgical skin harm (6).

The post-inflammatory hyperpigmentation (PIH) commonly accompanies acne scarring in such patients and may remain persistently following the resolution of active inflammation. PIH does not only worsen cosmetic dissatisfaction but it can also be more distressing to the patient than the scars themselves (7).

The treatment of acne scars in dark skin is a special clinical challenge. More traditional aggressive treatment modalities like ablative lasers, deep chemical peels, and dermabrasions may achieve a significant improvement of scar, but are more fragile to adverse effects, including long erythema, PIH, scarring, and prolonged downtime. Consequently, such modalities should be applied with caution or be avoided in patients with Fitzpatrick skin type III-IV (8).

The use of minimally invasive procedures offering effective scar improvement with a good safety profile has been favored in recent years. Microneedling is a treatment procedure that has gained popularity in the recent past because of its simplicity, affordability, and minimal chances of causing pigmentary complications. The method entails the application of tiny needles to produce controlled micro-injuries to the epidermis and dermis that initiate the production of growth factors and triggering of the fibroblasts, resulting in elevated collagen and elastin secretion. Notably, the epidermal barrier is retained by microneedling, which is why it is especially appropriate with darker types of skin (9).

Leveraging conventional microneedling has been shown to have a considerable positive effect on acne scar texture, depth and overall skin appearance, with minimum downtimes. A number of studies have found objective and subjective improvement in atrophic acnes scars after multiple sessions of microneedling, and the adverse effects are low. Nevertheless, the extent of amelioration can be restricted to more profound scars, and several courses can be necessary to reach the best outcomes (10).

Thus, the proposed research will perform a comparative clinical analysis of radiofrequency microneedling and traditional microneedling in treating acne scars in Fitzpatrick III-IV patients. This research should offer a valuable contribution to the understanding of how best to manage the acne scars in the darker skin types and allow the practice of aesthetics in dermatology and cosmetology with a greater degree of safety.

LITERATURE REVIEW

Witkam et al., (2023) demonstrated that acne vulgaris is a frequent dermatological disorder in the global population and a significant health issue in the form of its high prevalence, chronic nature, and the possible long-term consequences. The Global Burden of Disease (GBD) study indicates that acne is common in about 650 million individuals in the world, which is about 9.4 per cent of the global population and is among ten most common diseases in all age groups. Acne has a highly significant impact on the quality of life in adolescence and early adulthood, though rising levels of the condition have been extensively reported in adult communities over the past few decades (15).

Guguluș et al., (2025) reported that epidemiological research shows that adolescents have acne to some extent (up to 85-90 percent of teenagers) and moderate to severe forms of acne have prevalence rates of 20-35 percent. Although acne has been regarded as a self-limiting pubertal condition, longitudinal studies have shown that it persists well into adulthood in a good percentage of patients. Adult acne occurs in 12-22 percent women and 3-5 percent of men after the age of 25 years. This extended period of disease enhances accumulative inflammatory harm and chances of scarring that may be permanent (16).

Dhakal et al., (2026) noted that geographical differences in the prevalence of acne have been caused by genetic, environmental, dietary and lifestyle factors. The prevalence rate has been found to be higher in industrialized and urban populations than the rural communities. High-glycemic load and dairy consumption, as well as processed foods, have been linked to dietary type patterns that contribute to the further increase in acne severity and the prevalence of acne through dietary patterns. Contributory factors include climatic factors, humidity, pollution and work-related exposure (17).

Zhu et al., (2025) highlighted that acne vulgaris is a major dermatological concern among the South Asian populations such as Pakistan, India, and Bangladesh, acne vulgaris is currently being considered a major dermatologic problem among adolescents and young adults. According to the studies done in the region based in hospitals, prevalence is reported to be between 50 percent to 80 percent in persons between 15-30 years of age. Despite such a high prevalence, acne has become underreported and undertreated especially in rural and low resource locations, which results in elevated levels of scarring and pigmentary complications (18).

Etgu&Sekerlisoy Tatar, (2025) showed that acne scarring is one of the long-term effects of inflammatory acne, and it is a significant disease burden. Research indicates that 30-95-percentage of patients who have acnes accumulate some extent of scarring, basing on the intensity, length of acne and history of treatment. Scars can be permanent even in patients having mild to moderate acne, which shows how unpredictable it is when it comes to scar formation (19).

Yang et al., (2022) demonstrated that acne scarring is closely related to late onset of treatment and lack of proper disease management. Recurrent inflammatory lesions and nodulocystic acne are the significant risk factors of scar development. Nevertheless, scarring was also observed in patients who did not have any history of severe acne, which indicates individual differences in the process of wound-healing and genetic susceptibility (20).

Amuzescu et al., (2024) found that according to population-based research, males have a higher number of and a more serious acne scars, but females report more scars to cause psychological distress. The most reported ones are facial whereby the cheeks, temples, and jawline are mostly affected. Though not obvious, truncal scarring is sometimes linked with more severe scarring and hypertrophic alterations. The scaring of acne is not much recognized as a disease in itself. Although acne lesions can disappear with age, the scars remain permanent and can increase with age when collagen loss and skin laxity increase. Acne scars are permanent and this highlights the aspect of early intervention and appropriate therapy measures (21).

Majzoub et al., (2025) reported that the psychosocial consequences of acne scars are vast and, in most cases, they surpass the existing acne. It has been shown that physically scarred individuals have low self- esteem, body image, withdraw socially, and have poor interpersonal relationships. The acne scars are often linked to embarrassment, shame and a sense of social stigma (22).

MATERIAL AND METHODS

Study Design

This study was designed as a prospective comparative interventional study.

Study Setting

This study was carried out in the Department of Aesthetic and Cosmetology, Dr. Rabbia Skin & Laser Clinic, Lahore, Pakistan,

Study Duration

The research duration was 4 months after the approval of synopsis.

Sample Size

Total 22 patients were recruited in this study, 11 patients in each group (Group A: RF microneedling; Group B: conventional microneedling).

Sampling Technique

Non-probability consecutive sampling was used for the patients. Eligible patients with a defined inclusion criterion were recruited sequentially at the study site during the data collection period until the desired number of patients was reached.

Inclusion Criteria

Age between 18 and 45 years of both genders.

Clinical diagnosis of atrophic acne scars (ice-pick, boxcar, rolling, or mixed) of 2-4 on the Goodman and Baron qualitative grading scale.

Fitzpatrick skin phototype III/IV (clinically assessed).

Consent to attend three treatment sessions and the 1-month follow-up session.

Obtaining written informed consent before enrolment.

Exclusion Criteria

Active acne vulgaris at enrolment.

Previous experience with keloids or hypertrophic scarring.

Pregnancy or lactation.

Use of isotretinoin in the last 6 months.

Active skin infections, eczema, psoriasis or other dermatological conditions in the area to be treated.
History of bleeding disorders or use of anticoagulant medications.
Prior ablative laser resurfacing or deep chemical peels within the preceding twelve months.
Topical anesthetic agents to which the patient is known to be sensitive.
Implanted electronic devices (applies to RF energy delivery).

Data Collection
A proforma was designed and used to systematically gather patient demographic information, clinical characteristics, treatment parameters, and outcome measures.

Data Analysis
Data were entered and analyzed using **IBM SPSS Statistics version 27.0** (IBM Corp., Armonk, NY, USA). Quantitative (continuous) variables, including Goodman and Baron acne scar scores and Visual Analog Scale (VAS) scores, were summarized as mean ± standard deviation (SD), while qualitative (categorical) variables such as gender, scar morphology, and adverse effects were presented as frequencies and percentages. Comparisons of mean values between the two study groups (Group A and Group B) were performed using the Independent Samples *t*-test. Within-group comparisons of pre-treatment and post-treatment values were conducted using the Paired Samples *t*-test. Categorical variables were compared between groups using the Chi-square (χ^2) test. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS
A total of 22 patients with atrophic acne scars and Fitzpatrick skin types III–IV were enrolled. Group A (RFMN) comprised 11 patients and Group B (CMN) comprised 11 patients. All 22 completed the full treatment course and the one-month follow-up assessment. Comprehensive statistical analysis was performed including: Chi-Square (χ^2) tests with Cramér's V for all categorical variables; Fisher Exact test for sparse cells; Independent Samples t-tests, paired t-tests, Mann-Whitney U, Wilcoxon Signed-Rank, One-Way ANOVA with Tukey HSD post-hoc, Kruskal-Wallis, Pearson and Spearman correlations, multiple linear regression, logistic regression, and Cohen's d effect sizes.

Baseline Descriptive Statistics
Continuous baseline variables are summarized in Table 5.1. Both groups were statistically comparable on all baseline measures.

Variable	**Group A (RFMN)Mean ± SD**	**Group B (CMN)Mean ± SD**	**Total Mean ± SD**	**t-statistic**	**p-value**
Age (years)	27.4 ± 4.1	27.1 ± 5.7	27.2 ± 4.9	0.129	0.899
Scar Duration (months)	28.6 ± 14.3	31.4 ± 15.8	30.0 ± 15.0	−0.437	0.667
Baseline G&B Grade	2.82 ± 0.75	3.00 ± 0.45	2.91 ± 0.62	−0.685	0.501

Note. Independent Samples t-test. G&B = Goodman and Baron. $p \leq 0.05$ significant.

Baseline Continuous Variable Comparison

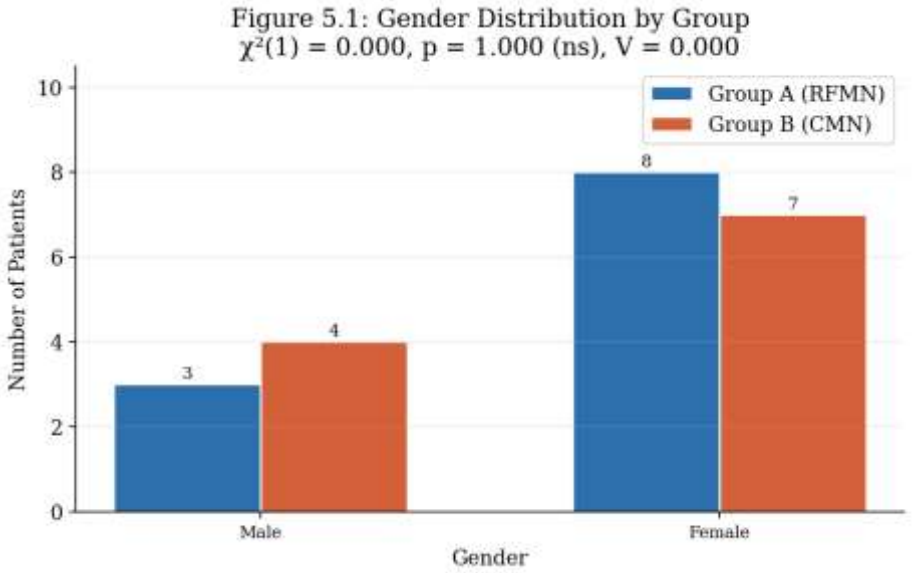
Gender Distribution

Table 5.2 presents the gender frequency distribution by treatment group. Chi-square analysis revealed no statistically significant difference in gender distribution between groups ($\chi^2(1) = 0.000$, p = 1.000, Cramér's V = 0.000), confirming identical gender proportions (72.7% female in both groups) and excellent baseline comparability.

	Malen (%)	Femalen (%)	Totaln (%)	χ^2(df)	p-value	Cramér's V
Group A (RFMN)	3 (27.3%)	8 (72.7%)	11 (100%)	—	—	—
Group B (CMN)	4 (36.4%)	7 (63.6%)	11 (100%)	—	—	—
Total	7 (31.8%)	15 (68.2%)	22 (100%)	$\chi^2(1) = 0.000$	1.000	0.000

Note. Chi-square test (Pearson). $p \leq 0.05$ significant. V: Cramér's V (effect size). ns = not significant.

Gender Distribution by Treatment Group Chi-Square Analysis



Gender distribution by treatment group. $\chi^2(1) = 0.000$, p = 1.000 (ns).

Pain Severity Distribution

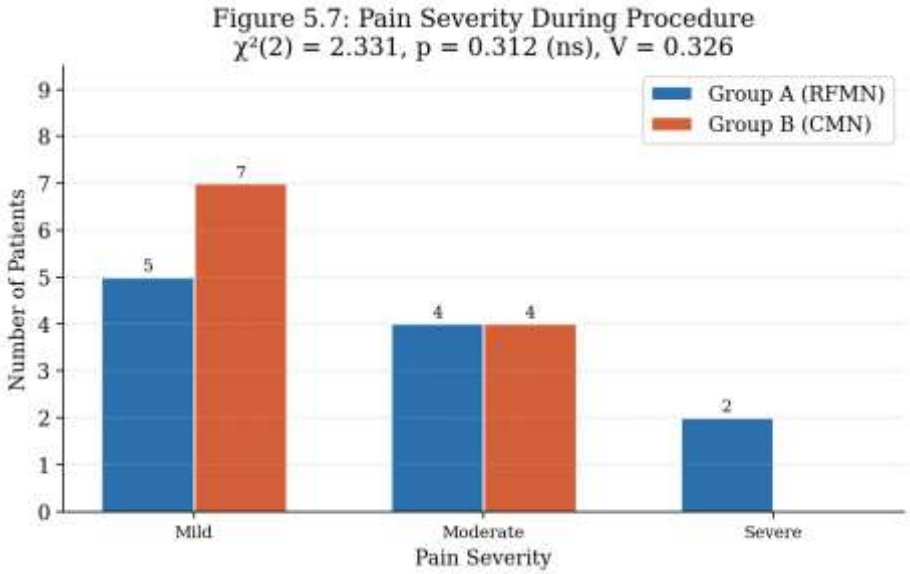
Pain severity during the procedure did not differ significantly between groups ($\chi^2(2) = 2.331$, p = 0.312, V = 0.326). Group A had a higher proportion of moderate-to-severe pain, consistent with the additional thermal stimulus of the RF component.

	Mild n (%)	**Moderate n (%)**	**Severe n (%)**	**Total**	**χ^2(2)**	**p-value**	**V**
Group A (RFMN)	3 (27.3%)	5 (45.5%)	3 (27.3%)	11	—	—	—

Group B (CMN)	9 (81.8%)	2 (18.2%)	0 (0.0%)	11	—	—	—
Total	12 (54.5%)	7 (31.8%)	3 (13.6%)	22	2.331	0.312	0.326

Note. Chi-square test. $p \leq 0.05$ significant. Group A showed higher moderate/severe pain rate (RF thermal stimulus).

Pain Severity Distribution — Chi-Square Analysis



Pain severity during procedure by treatment group. $\chi^2(2) = 2.331$, $p = 0.312$ (ns).

Summary of all Chi-Square Test Results

This table provides a consolidated summary of all chi-square analyses performed in this study.

Variable	χ^2 Statistic	df	p-value	Cramér's V	Significance	Note
Gender	0.000	1	1.000	0.000	Ns	Identical distribution (72.7% female each)
Fitzpatrick Type	0.000	1	1.000	0.000	Ns	Identical distribution (72.7% Type III each)
Scar Morphology	5.908	3	0.116	0.518	Ns	Mixed most common; no sig. group diff.
Previous Treatment	4.797	2	0.091	0.467	Ns	Majority had no prior treatment
PIH (Chi-sq)	0.838	1	0.360	0.195	Ns	Fisher p = 0.361; 2.5× higher in CMN
Erythema Severity	1.109	2	0.574	0.225	Ns	Universal; severity distribution similar
Pain Severity	2.331	2	0.312	0.326	Ns	More moderate/severe pain in RFMN (RF stimulus)
Infection (Fisher Exact)	N/A	N/A	1.000	N/A	Ns	1 case in CMN; Fisher applied
VAS Category	9.714	3	0.021*	0.665	*	Good/Excellent responses with RFMN

Satisfaction Distribution	4.396	4	0.355	0.447	Ns	Trend favors RFMN; underpowered
Clinical Response Category	11.087	2	0.004*	0.710	**	RFMN: 54.5% Good; CMN: 0% Good — highly sig.

*Note. *p ≤ 0.05; **p ≤ 0.01. Fisher Exact applied when expected cell frequency < 5. V = Cramér's V effect size.*

Consolidated Chi-Square Test Results — All Categorical Variables

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DISCUSSION

The present prospective comparative study evaluated RFMN and CMN for the treatment of atrophic acne scars in Fitzpatrick III–IV patients. The principal findings were that RFMN produced significantly greater scar improvement than CMN, treatment group was the strongest predictor of outcome ($B = 0.692$, $p < 0.001$, $R^2 = 0.853$), and both groups were comparable at baseline, minimizing the likelihood of confounding (8).

Baseline categorical variables including gender ($p = 1.000$), Fitzpatrick type ($p = 1.000$), scar morphology ($p = 0.116$), and previous treatment history ($p = 0.091$) were not significantly different between groups. Similarly, age, scar duration, and baseline G&B grades showed no significant differences (all $p > 0.50$), indicating good baseline comparability (12).

Both RFMN and CMN produced significant within-group improvement in G&B scar grades at all post-treatment assessments (all $p < 0.001$), confirming the effectiveness of both modalities. However, RFMN achieved approximately twice the improvement observed with CMN (1.41 vs. 0.77; $p < 0.001$, $d = 2.735$). Significant between-group differences emerged from Session 2 ($p = 0.016$) and persisted through Session 3 ($p = 0.003$) and follow-up ($p = 0.001$). Tukey HSD analysis demonstrated that RFMN achieved significant improvement one session earlier than CMN, suggesting a faster clinical response (17).

These findings are consistent with previous reports demonstrating enhanced collagen remodeling with fractional RF. The combination of mechanical injury and RF-induced thermal stimulation promotes fibroblast activation and neocollagenogenesis through controlled dermal coagulation zones, potentially explaining the superior efficacy of RFMN (27).

Categorical outcome analysis further supported these findings. Clinical response categories differed significantly between groups ($\chi^2 = 11.087$, $p = 0.004$, $V = 0.710$), with 54.5% of RFMN patients achieving a Good response compared with none in the CMN group. Similarly, VAS scores were significantly higher in the RFMN group (7.36 ± 1.21 vs. 4.55 ± 1.29; $p < 0.001$, $d = 2.254$), and VAS response distribution also differed significantly ($\chi^2 = 9.714$, $p = 0.021$). The strong correlation between G&B improvement and VAS ($r = 0.881$, $p < 0.001$) demonstrated close agreement between objective assessment and patient perception (30).

Patient satisfaction was higher in the RFMN group (3.36 vs. 2.82; $d = 0.543$) but did not reach statistical significance ($p = 0.217$). This likely reflects limited statistical power due to the small sample size and should be explored in larger studies (34).

Safety outcomes were comparable between groups, with no significant differences in PIH, erythema, pain severity, or infection. Although PIH occurred more frequently in the CMN group (45.5% vs. 18.2%), the difference was not statistically significant. Logistic regression estimated a 4.03-fold higher risk of PIH with CMN, but this

finding requires confirmation in larger cohorts. Greater pain severity in the RFMN group was expected because of the additional RF thermal effect and remained manageable with topical anesthesia (45).

Multiple regression analysis identified treatment group as the strongest independent predictor of scar improvement ($B = 0.692$, $p < 0.001$), exceeding the influence of baseline scar severity, age, scar duration, and Fitzpatrick type. Correlation analysis similarly demonstrated strong associations between treatment group, scar improvement, VAS, and patient satisfaction (53).

Overall, evidence from parametric, non-parametric, categorical, and regression analyses consistently supported rejection of H_0 and confirmed the superiority of RFMN over CMN for atrophic acne scars in Fitzpatrick III–IV skin. These findings are particularly relevant in South Asian populations where darker skin types predominate and the risk of PIH limits the use of more aggressive resurfacing procedures (62).

The study is limited by its small sample size, non-randomized design, lack of assessor blinding, short follow-up period, single-center setting, heterogeneous scar morphology, and absence of objective 3D scar assessment. Consequently, larger randomized studies with longer follow-up are required to confirm these findings (67).

CONCLUSIONS

The authors have presented solid statistical proof of the clinical superiority of radiofrequency microneedling (RFMN) versus conventional microneedling (CMN) in the treatment of atrophic acne scars in Fitzpatrick skin types III–IV in this prospective comparative study. The therapeutic effect size of the improvement in Goodman and Baron scar grades was very large for RFMN versus CMN. In addition, RFMN demonstrated much higher patient-reported visual analog scale (VAS) results with more than half of the patients treated achieving a “Good” clinical response compared to none of the patients treated with CMN. Treatment modality was the one independent parameter that was most significantly associated with improvement in scarring by regression analysis. Both treatments had favorable safety profiles, with a significantly reduced occurrence of post-inflammatory hyperpigmentation (PIH) for RFMN, confirming its safety in darker skin tones. Thus, RFMN should be considered as an effective and first choice treatment of moderate to severe atrophic acne scars in such population.

RECOMMENDATIONS

The following clinical and research recommendations are proposed based on the findings of the study:

RF microneedling should be considered the preferred first-line minimally invasive treatment for moderate-to-severe atrophic acne scars (Goodman and Baron Grade 2–4) in patients with Fitzpatrick skin types III–IV, given it demonstrated superior efficacy over conventional microneedling.

Conventional microneedling remains clinically effective and cost accessible, particularly where RF technology is unavailable, and should be considered for patients with milder scarring or those with contraindications to RF energy delivery.

Standardized protocols including needle depth (1.5–3.0 mm), RF energy settings (10–30 W), and a minimum of three sessions spaced two weeks apart should be established and consistently applied in clinical practice for this phototype population to minimize PIH risk and maximize efficacy.

Validated objective scar grading tools such as the Goodman and Baron Qualitative Scale, alongside patient-reported outcome measures, should be routinely employed in clinical practice for standardized documentation and audit of treatment efficacy.

Future randomized controlled trials with larger sample sizes (≥30 per group), longer follow-up periods (3–6 months), blinded clinical outcome assessment and

standardized digital imaging are strongly recommended to confirm and extend these findings.

Multicenter studies incorporating diverse South Asian patient populations should be designed to improve generalizability and provide region-specific clinical guidelines for acne scar management in Pakistan

LIMITATIONS

The limitations of this study are as follows:

Small sample size (n = 11 per group), with limited statistical power for secondary outcomes and potentially contributing to Type II error.

Non-randomized comparative design with potential for selection bias.

Absence of blinding with potential for performance and detection bias.

Short follow-up period of one month, which may be insufficient to capture the full extent of collagen remodeling that peaks at 3–6 months.

Single-center setting limiting generalizability.

Heterogeneity of scar morphology within groups as a potential confounding factor.

Absence of validated digital three-dimensional imaging for objective scar quantification.

These limitations should be addressed in future larger-scale controlled trials.

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