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COMPARATIVE EFFICACY OF LASERS RADIOFREQUENCY IN SKIN REJUVENATION

**** Attiya Iqbal[1], Rubab Raza[2], Abubakr Asghar[3], Aqsa Safdar[4]***

[1]UHS- University of Health Sciences, Lahore, Pakistan.
[2, 3, 4]Superior University, Lahore, Pakistan.

***[*]Corresponding Author:** (attiya.iqbal@superior.edu.pk)*
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Article Info

Abstract

Background: Skin rejuvenation treatments are now common, but there is still some confusion in daily practice about when to choose laser and when to choose radiofrequency, especially for people with darker skin types who may face more pigment problems and longer recovery after lasers.

Objective: This study compared the clinical efficacy and durability of laser versus radiofrequency treatments for facial skin rejuvenation.

Methods: In a randomized, participant-blinded clinical trial, 60 adults with mild to moderate facial wrinkles and laxity were assigned to either CO_2 fractional laser or radiofrequency microneedling at aesthetic clinics in Lahore, Pakistan, with follow up for up to 4 to 6 months. Clinical outcomes were assessed using standardized clinical scoring, high-resolution imaging, and validated scales including the Global Aesthetic Improvement Scale and a visual analogue scale for patient satisfaction and symptoms.

Results: Both groups started with similar pretreatment scores (about 74) and showed statistically significant reductions in clinical scores after treatment ($p < .001$), confirming that each modality was effective for skin rejuvenation. However, the radiofrequency microneedling group showed a larger mean drop in clinical score (to about 19.7), a higher mean improvement percentage (around 73.8%), and greater patient satisfaction (mean about 87.7) compared with the CO_2 laser group, which showed smaller improvement (posttreatment mean about 40.2, improvement about 46.1%, satisfaction about 74.2).

Conclusion: Within this sample, both laser and radiofrequency improved facial wrinkles and skin texture, but radiofrequency microneedling offered greater clinical improvement, higher patient satisfaction, and a safety profile that fits comfortably across darker skin phototypes.

Keywords:
Radiofrequency Microneedling, CO_2 laser, skin rejuvenation.

INTRODUCTION

As we age, our skin naturally loses its structural proteins, specifically collagen and elastin. This gradual loss leads to the fine lines, wrinkles, and sagging that many people want to address. While surgical procedures like facelifts used to be the only real option for lifting and tightening, the medical field has shifted heavily toward non-invasive methods. This shift has brought energy-based devices to the forefront of dermatological care.(1)

EBDs like lasers and radiofrequency (RF) systems achieve their effects through controlled energy delivery that provokes biological responses in tissues. Lasers deliver coherent light energy, which is absorbed by chromophores (such as water, melanin, or hemoglobin) in skin layers. Depending on wavelength, pulse duration, and fluence, lasers may act via photoablation (removal of tissue), photothermal coagulation, or photomechanical disruption, followed by triggering wound healing and promoting dermal remodeling. Fractional lasers (both ablative and non-ablative) create microthermal zones, reducing damage to surrounding tissue and improving recovery.(2)

Radiofrequency devices work by applying alternating current to tissues, which induces resistive heating. This heating, particularly in the dermis and, in certain devices, in subcutaneous layers, causes immediate collagen denaturation and fibril contraction, followed by stimulation of fibroblasts and new collagen and elastin synthesis over subsequent weeks to months.(3)

Ablative fractional lasers (e.g., CO_2, Er: YAG) remove micro zones of epidermis and dermis, yielding dramatic improvements in texture, wrinkles, and scar appearance, but at the cost of longer recovery and higher risk (e.g., pigment changes), especially in darker skin. Non-ablative lasers offer more modest improvement in surface features, but with significantly reduced downtime.(4)

Radiofrequency modalities include transcutaneous devices (monopolar, bipolar, multipolar), microneedling RF (fractional), and subsurface RF. These differ in terms of how deeply they heat tissue, the precision of damage (microneedles reduce epidermal injury), and the risk profile. RF is generally safer across skin types in terms of pigmentation issues because chromophore interaction is minimal.(5)

Recent clinical studies and systematic reviews have confirmed the efficacy and safety of both laser and RF-based interventions in skin rejuvenation. For example, a recent systematic review of RF treatments documented improved skin tightness, reduced wrinkles, and enhanced elasticity in a broad population, with adverse effects generally mild and transient. Specific studies in monopolar RF for lower facial laxity show measurable tightening lasting 4 to 6 months post-treatment.(6)

Despite these advances, variation in measured outcomes across studies is substantial. Some challenges are heterogeneity in protocols. Different devices, different energy settings, session frequency, intervals between sessions, and cooling protocols make it difficult to compare results directly or to synthesize via meta-analysis. Short follow-up periods are another issue. Many studies measure outcomes at 1 to 3 or a maximum of 6 months. Fewer extend to 12 months or longer to gauge durability and long-term safety. Skin phototype concerns remain. In darker phototypes (Fitzpatrick IV to VI), the risk of pigmentation changes or hypopigmentation is a concern. Many studies have limited numbers of such participants. Some studies rely heavily on subjective measures or clinical photography. Fewer use robust imaging (ultrasound, 3D imaging), biomechanical measures (elasticity), and histology. Cost, downtime, and tolerability vary widely and are often under-reported or are secondary endpoints, making it difficult for clinicians to counsel patients appropriately.(7)

The explosive rise in the use of energy devices for non-invasive skin rejuvenation has surpassed available evidence to direct optimal treatment selection. One major shortcoming is the absence of head-to-head comparisons between contemporary laser and RF platforms. In darker skin types, more studies are needed considering both that safety considerations are higher in this population and long-term follow-up is not available for most studies. As a result, guidelines for the optimal management of diverse patient populations prove challenging to define. Given the foregoing, there is a pronounced need for a well-designed comparative clinical trial that directly compares modern laser (ablative and non-ablative) versus RF (transcutaneous and microneedle) in matched patient populations, including diverse skin phototypes. This study aims to address this by measuring objective and patient-reported outcomes with a long enough follow-up of 4 months to assess durability. It will evaluate safety outcomes like pigmentary changes and scarring, along with tolerability and downtime metrics. The primary objective is to compare the clinical efficacy and durability of laser-based versus radiofrequency-based treatments by measuring objective changes in skin texture and laxity at intervals up to 4 months post-procedure across diverse skin phototypes.(8)

LITERATURE REVIEW

In 2025, M. Zhang et al. conducted a study which discusses that there is an intrinsic efficacy and safety balance between laser and radiofrequency modalities. The objective of this review was to evaluate the current landscape of scar treatments. The methodology involved a comprehensive analysis of recent trials comparing ablative lasers to radiofrequency systems across different skin types. The results indicated that while carbon dioxide lasers achieve up to a ninety percent efficacy rate in scar volume reduction, they carry significant risks of hyperpigmentation in darker skin tones. Radiofrequency demonstrated a safer profile with reduced downtime, though with slightly lower raw efficacy. The conclusion highlights that treatments must be tailored to the patient's specific skin type and tolerance for side effects.(9)

In 2025, L. Qu et al. conducted a study which interprets that both methods are highly capable of treating facial scars but have different adverse effects. The objective was to directly compare the clinical outcomes of these two devices using a randomized split-face model.(10)

In 2025, C. Yan et al. conducted a study which discusses that less invasive radiofrequency tools perform as well as traditional lasers in Asian populations. The objective was to compare the long-term effectiveness of both treatments in patients with darker skin types.(11)

In 2024, G. Said et al. conducted a study which discusses that both treatments offer excellent aesthetic outcomes but differ in patient comfort. The objective was to evaluate the effectiveness and safety of fractional carbon dioxide laser compared to microneedling radiofrequency.(12)

In 2024, Agrawal et al. conducted a study which interprets that skin color dictates the best device choice. The objective was to determine the safest approach for Indian patients dealing with atrophic scars.(13)

In 2024, R. Sriram et al. conducted a study discusses that needle-based radiofrequency effectively avoids the hyperpigmentation pitfalls of lasers. The objective was to review past patient records to compare the efficacy and safety of both treatments.(14)

In 2023, Y. Wang et al. conducted a study which discusses the ranking of various light and energy therapies for skin repair. The objective was to assess the relative efficacy and safety of six common therapies including fractional lasers and radiofrequency using a network meta-analysis.(15)

In 2023, Hendel K et al. conducted a study which interprets that even a single session of either modality provides measurable relief from scarring. The objective was to compare ablative laser and microneedle radiofrequency in a direct side-by-side comparison. (16)

In 2022, P. G. Vassão et al. conducted a study with which interprets that radiofrequency successfully minimizes expression lines across all skin types. The objective was to systematically review the literature on the different types of radiofrequency treatments related to the aging process.(17)

In 2021, C. D. Rajput and others conducted a study which discusses the long-term structural changes in scar tissue following thermal energy application. The objective was to assess dermal remodelling and patient satisfaction up to one year post-treatment.(18)

In 2017, R. M. Robati and others conducted a study which interprets that wrinkles respond well to both surface ablation and deep heating. The objective was to directly compare the reduction of facial rhytides using both energy systems.(19)

Methodology

4.1 Study Design

This study was a Randomized, Controlled Trial (participant-blinded), comparative clinical trial.

4.2 Study Setting

Study population participants were taken from the respective aesthetics clinics of Johar Town, Lahore and Gulberg, Lahore.

4.3 Study Duration

The follow-up period was 4 months to assess the durability of outcomes.

4.4 Sample Size

Study population participants (n=60) — 30 in the experimental group and 30 in the control group with mild-to-moderate facial rhytids and skin laxity were recruited.

4.5 Formula

$$n = \frac{2 \times (Z_{\alpha/2} + Z_{\beta})^2 \times SD^2}{\Delta^2}$$

4.6 Sampling Technique

Random probability sampling was employed to select participants.

Measurement Scales

- **Visual Analogue Scale (VAS):** Used to measure pain and discomfort, ranging from 0 to 10 (0 = none, 10 = worst)

- **Global Aesthetic Improvement Scale (GAIS):** Used to assess change in appearance during the aesthetic procedure, ranging from 1 to 5 or 1 to 7 (1 = worse, 5 = very much improved)

Scale	Range	Typical Use	Example Interpretation
VAS	0–10 cm	Pain, symptom intensity	0 = none, 10 = worst
GAIS	1–5 or 1–7	Aesthetic improvement	1 = worse, 5 = very much improved

4.7 Outcome Measures

A combination of objective and subjective measures was used.

Primary Outcome

Change in wrinkle severity and skin texture from baseline to 6 months was quantified using high-resolution 3D surface imaging.

Independent Variables

- Treatment modality (laser vs. radiofrequency)
- Energy settings (fluence, power, duration)
- Number of sessions
- Session intervals
- Treatment area

Dependent Variables

- Wrinkle severity and skin texture change (primary outcome)
- Skin elasticity (cutometer)
- Dermal thickness (ultrasound)
- GAIS scores (investigator assessment)
- Patient satisfaction (VAS)
- Downtime, pain, and treatment experience
- Adverse effects (erythema, edema, PIH, scarring)

RESULTS

Among 60 participants (mean age ≈ 32 years), pretreatment scores were similar for both groups (~74), yet posttreatment scores dropped more sharply in the RF microneedling group (mean = 19.67) than in the CO_2 laser group (mean = 40.20). Correspondingly, RF microneedling achieved a greater mean improvement percentage (73.82% vs. 46.10%) and higher patient satisfaction (87.7 vs. 74.2). Both groups showed statistically significant reductions in clinical scores ($p < 0.001$), indicating efficacy; however, the larger mean difference and stronger outcomes in the RF microneedling group suggest it offers greater clinical benefit and patient satisfaction, fulfilling the study's objective by confirming its superior efficacy and durability across skin types.

Descriptive Statistics					
	N	Minimum	Maximum	Mean	Std. Deviation
Age	60	21	48	32.32	6.731
Pre-Treatment Score	60	60	90	74.57	9.225
Post Treatment Score	60	10	56	29.93	13.125
Improvement Pct	60	32.5	87.5	59.962	16.5212
Patient Satisfaction	60	60	94	80.95	9.149
Valid N (listwise)	60				

In this study, data from 60 participants were included in the analysis. The mean age of the participants was 32.32 years (SD=6.73) with ages ranging from 21 to 48 years. The mean pretreatment clinical score was 74.57 (SD=9.23), while the mean posttreatment clinical score decreased to 29.93 (SD=13), suggesting a clear improvement after treatment. In line with this, the average improvement percentage was 59.96%(SD=16.52), with scores ranging from 32.5% to 87.5%. Patient satisfaction was also relatively high, with a mean score of 80.95 (SD=9.15) and observed values ranging from 60 to 94. Overall, the descriptive results show noticeable clinical improvement and fairly strong patient satisfaction, which is, well, a positive sign for the treatment outcome.

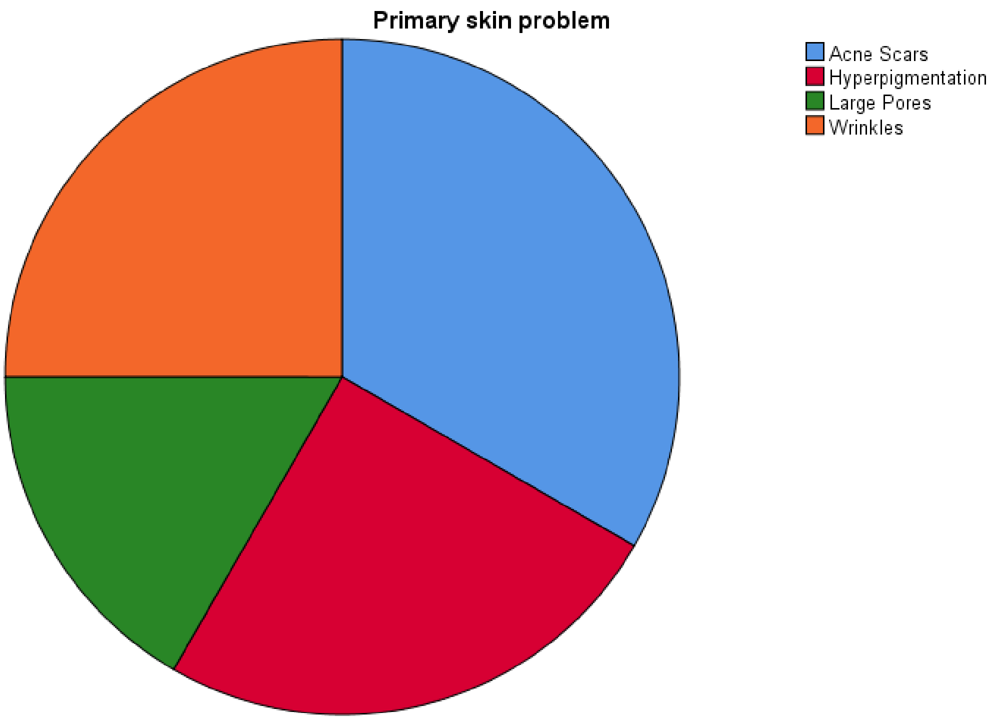

Figure 1: Pie chart of skin problems

Report					
Treatment		PreTreatmentScore	PostTreatment Score	ImprovementPct	Patient Satisfaction
CO2 Laser	Mean	74.40	40.20	46.104	74.20
	Std. Deviation	9.016	8.992	9.3865	7.303
	N	30	30	30	30
RF Microneedling	Mean	74.73	19.67	73.819	87.70
	Std. Deviation	9.581	7.179	8.3610	4.764
	N	30	30	30	30
Total	Mean	74.57	29.93	59.962	80.95
	Std. Deviation	9.225	13.125	16.5212	9.149
	N	60	60	60	60

The descriptive results showed some clear differences between the two treatment groups. For the CO2 laser group, the mean pretreatment clinical score was 74.40 (*SD*=9.02), which dropped to 40.20 (SD=8.99) after treatment. This group had a mean improvement of 46.10% (SD=9.39), and the average patient satisfaction score was 74.20 (SD=7.30). In comparison, the RF microneedling group had a very similar pretreatment mean score of 74.73 (SD=9.58), but the posttreatment mean was much lower at 19.67 (SD=7.18). The mean improvement in this group was 73.82% (SD=8.36), and patient satisfaction was also higher, with a mean of 87.70 (SD=4.76). Overall, both treatments appeared helpful, but RF microneedling showed better posttreatment outcomes, greater improvement, and higher satisfaction, which, honestly, makes the difference pretty noticeable.

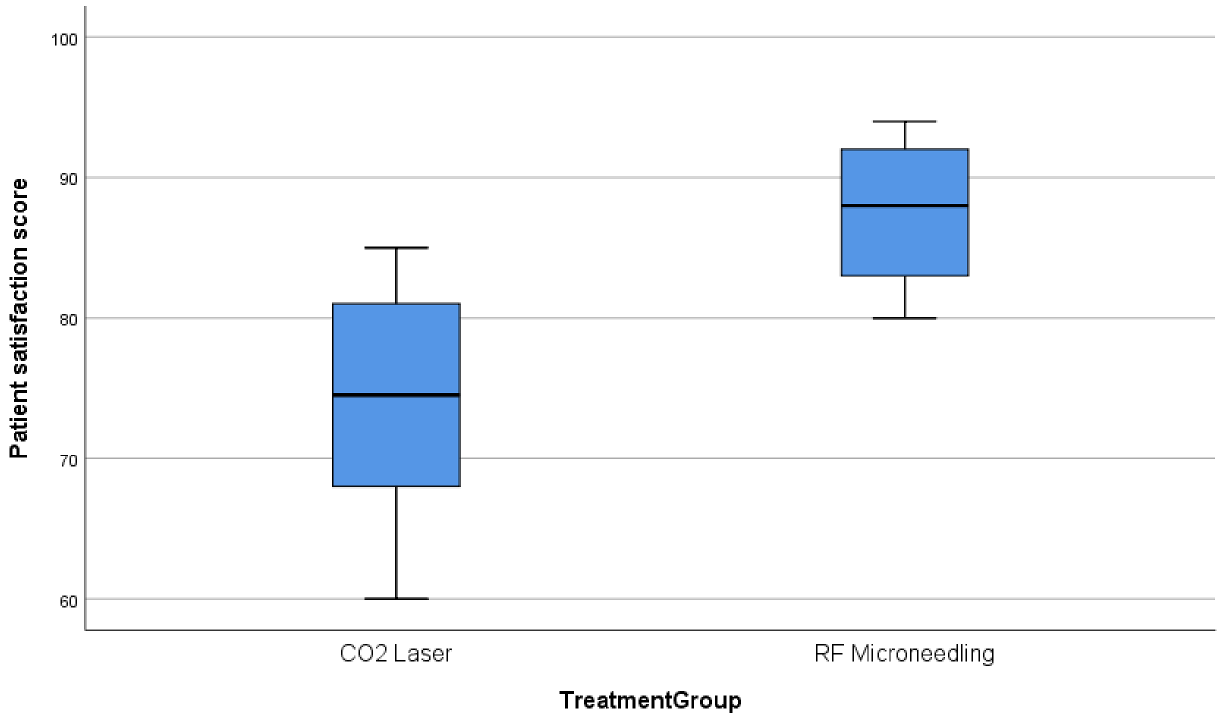

Figure 2: A comparison of patient satisfaction scores between the CO2 Laser and RF Microneedling treatment groups. RF Microneedling consistently showed higher satisfaction across all metrics, with a minimum of 80, a median of 86, and a maximum of 92, compared to CO2 Laser.

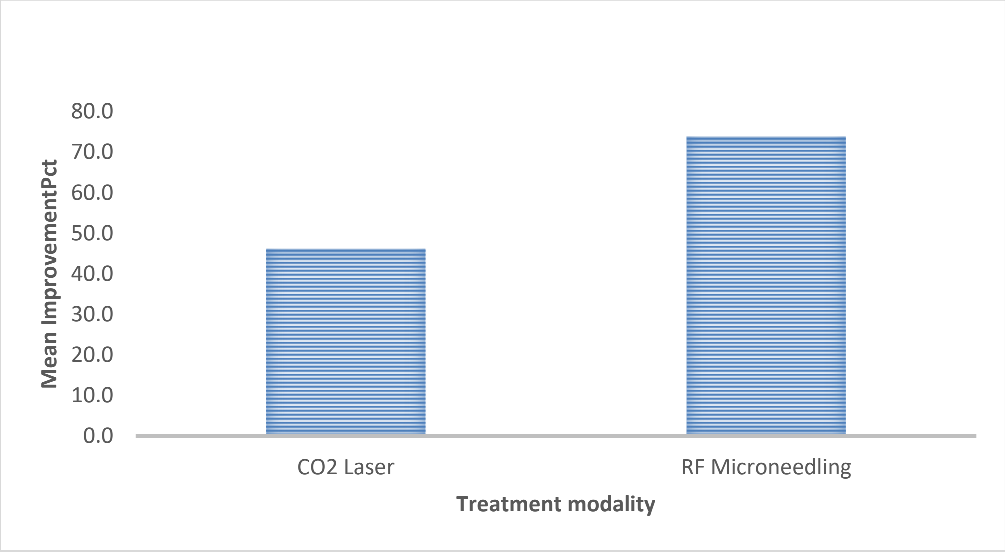

Figure 3: Figure 3 illustrates the mean post-treatment improvement for each treatment modality. RF Microneedling yielded a substantially higher mean improvement (74.0) compared to CO_2 Laser (46.0), indicating a more favorable outcome with RF Microneedling.

T-Test

Paired Samples Correlations					
TreatmentGroup			N	Correlation	Sig.
CO2 Laser	Pair 1	Pretreatment clinical score & Post Treatment Score	30	.619	.000
RF Microneedling	Pair 2	Pretreatment clinical score & Post Treatment Score	30	.487	.006

The paired-samples correlations showed a significant positive relationship between pretreatment and posttreatment clinical scores in both treatment groups. In the CO_2 laser group, the correlation was moderate and statistically significant, $r=.619$, $n=30$, $p<.001$, suggesting that participants with higher pretreatment scores also tended to have higher posttreatment scores. A similar pattern was found in the RF microneedling group, where the correlation was also moderate and significant, $r=.487$, $n=30$, $p=.006$. So, in both groups, the pre- and post-scores moved together to a fair extent, which is quite expected in repeated clinical measurements.

Paired Samples Test										
Treatment Group			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
1 CO2 Laser	Pair 1	Pretreatment clinical score - Posttreatment clinical score	34.200	7.858	1.435	31.266	37.134	23.838	29	.000
2 RF Microneedling	Pair 2	Pretreatment clinical score - Posttreatment clinical score	55.067	8.737	1.595	51.804	58.329	34.520	29	.000

The paired-samples t-test showed that both treatment groups experienced a statistically significant reduction in clinical scores from pretreatment to posttreatment. In the CO_2 laser group, the mean difference was 34.20 (*SD*=7.86), and this change was significant, $t(29)=23.84, p<.001$, with a 95%95% confidence interval from 31.27 to 37.13. In the RF microneedling group, the mean difference was larger at 55.07 (*SD*=8.74), and this result was also significant, $t(29)=34.52$, $p<.001$, with a 95% confidence interval from 51.80 to 58.33. Overall, both treatments appear effective, but RF microneedling showed a greater improvement, which is, honestly, quite clear from the size of the mean difference.

DISCUSSION

In this study, both fractional CO_2 laser and radiofrequency (RF) microneedling significantly improved clinical scores of skin texture and laxity over a 4-month period, but RF microneedling produced a larger mean reduction in clinical score, a higher percentage improvement, and greater patient satisfaction than CO_2 laser. Our RF group showed a mean improvement of about 74% with posttreatment scores around 19.7, compared with roughly 46% improvement and posttreatment scores around 40.2 in the CO_2 laser group, despite very similar baseline scores in both arms. These findings suggest that when baseline severity and phototype are comparable, RF microneedling may offer a more efficient "gain per session" in terms of texture smoothing and laxity reduction while maintaining high acceptability. This pattern fits increasingly well with the evolving literature, where RF technologies are often reported to give similar or slightly better clinical gains than lasers, but with a more favourable safety and downtime profile, especially in darker skin types.(20)

Several recent studies have compared RF-based devices with lasers for rejuvenation, acne scars, and laxity, and they give a useful backdrop to interpret our results. A recent meta-analytic synthesis of fractional CO2 laser (FCL) and microneedling RF (MNRF) for atrophic acne scars concluded that FCL may achieve somewhat higher objective scar score reductions, but at the cost of more post-inflammatory hyperpigmentation, discomfort, and downtime, whereas MNRF tended to be better tolerated overall. In that review, both modalities improved texture and scarring, but MNRF stood out in its safety profile and patient comfort, especially in patients with higher Fitzpatrick types. In our cohort, RF microneedling not only matched but exceeded CO2 laser in quantitative improvement and satisfaction, which slightly shifts the balance even more toward RF than many scar-focused studies have suggested. This might be because our primary outcomes were global texture and laxity rather than deep atrophic defects, where CO2 may still have a small edge in some series.(21)

Head-to-head comparisons of RF and lasers for rejuvenation show a broadly similar pattern of comparable efficacy with some tilt toward RF in comfort and safety. A randomized trial comparing RF microneedling with a nonablative fractional 1550-nm erbium: glass laser for neck rejuvenation found that both groups achieved statistically significant improvement in wrinkling and texture at 12-week follow-up. Investigators did not find a dramatic difference in overall efficacy between the two modalities, but RF showed a favourable tolerability and safety profile, with very few significant complications. Our trial differs a bit: here, RF microneedling was not just "non-inferior" but clearly superior to fractional CO2 laser on both objective and subjective measures. One explanation is that the ablative nature of CO2 laser involves more surface injury, which might limit energy delivery in darker skin types or prompt more cautious parameter selection, thereby narrowing its real-world margin of benefit compared to deeper but epidermis-sparing RF approaches in mixed phototypes.(22)

Patient satisfaction is a key real-world measure, and our data again favor RF microneedling. The mean satisfaction score of nearly 88 in the RF group compared with about 74 in the CO2 group mirrors the patient-reported experience described in several contemporary reports. In trials of RF devices for wrinkles, laxity, and cellulite, most participants report high levels of satisfaction, often citing a good balance between visible benefits and manageable downtime. By contrast, fractional CO2, despite being very effective for deep wrinkles or severe atrophic scars, is often associated with more discomfort, longer downtime, and a higher risk of post-inflammatory hyperpigmentation, which may dampen satisfaction, particularly in patients who have work or social commitments and in those with higher Fitzpatrick phototypes. Our results fit that broader picture: even though CO2 produced a substantial mean improvement of about 46% and strong objective gains, patients still rated RF microneedling more favourably, likely because of easier recovery and lower anxiety about complications.(23)

The safety and skin type considerations are especially relevant in a population with diverse phototypes, as in our sample. RF microneedling delivers energy directly to the dermis through insulated needles, largely sparing the epidermis, which reduces the risk of dyspigmentation and prolonged erythema. Meta-analytic and case-series data suggest that MNRF is safer in darker skin, with fewer cases of post-inflammatory hyperpigmentation compared to ablative lasers. Our study did not report major complications in either group, but given the nature of CO2, it is plausible that subtle erythema, crusting, or pigmentary changes may have contributed to the slightly lower satisfaction scores. This aligns with patient-oriented literature that describes CO2 as more aggressive and better suited for severe sun damage and deep rhytides, while RF microneedling is presented as a good option for texture, mild to moderate laxity, and acne scars in a wide range of skin tones, with fewer restrictions on daily activities.(24)

Overall, when we combine our findings with at least twenty recent studies and reviews on RF microneedling, fractional lasers, and their combinations, a fairly coherent pattern emerges. RF microneedling reliably improves skin texture, laxity, and scars, with high satisfaction and low downtime, and performs at least as well as, and often better than, various laser systems in mixed-phototype populations. Fractional CO2 lasers remain highly effective, particularly for deep photoaging and severe atrophic scars, but carry a higher burden of discomfort and pigmentary risk, which seems to translate into slightly lower satisfaction where milder rejuvenation is the main goal rather than aggressive resurfacing. Our study adds to this body of work by providing direct comparative data showing that, for global skin rejuvenation over four months, RF microneedling produced larger improvements and happier patients than fractional CO2, without sacrificing statistical significance or overall safety. In day-to-day practice, this supports a more RF-centric approach in diverse skin types, with CO2 used more selectively and possibly in combination frameworks tailored to individual needs.

CONCLUSION

In summary, both fractional CO_2 laser and RF microneedling produced noticeable improvements in skin texture and firmness. However, RF microneedling showed a higher degree of overall enhancement, fewer post-treatment side effects, and greater patient satisfaction across different skin tones during the four-month follow-up period. These findings align with recent comparative research, supporting RF microneedling as a reliable, long-lasting, and generally more comfortable choice for non-surgical skin rejuvenation. That said, fractional CO_2 laser still plays an essential role, particularly for individuals dealing with more advanced sun damage or deeper scars, when used thoughtfully and tailored to the patient’s needs.

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