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REVIEW

Fractional Radiofrequency Microneedling as a Monotherapy in Acne Scar Management: A Systematic Review of Current Evidence

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Abstract: Fractional radiofrequency microneedling (FRM) is a popular, minimally invasive skin rejuvenation modality for treating acne scarring. In this study, we aimed to systematically evaluate the current literature on the efficacy and safety of FRM as a monotherapy to treat different types of facial acne scarring. We systematically reviewed all available literature on FRM techniques used for acne scarring by searching the PubMed and EBSCO databases up to July 2024. 16 studies involving 481 patients, comprising six prospective studies, six randomized clinical trials, three retrospective studies, and one comparative trial, were included. FRM is likely an effective treatment for acne scarring when used as a monotherapy. Further randomized controlled trials are needed to establish appropriate treatment parameters.

Keywords: fractional radiofrequency microneedling, monotherapy treatment, acne scarring

Introduction

Minimally invasive procedures for acne scar treatment with minimal downtime are becoming essential in dermatology practice.[1–3] Despite multiple modalities for treating acne scarring, the introduction of fractional radiofrequency microneedling (FRM) has provided a safe and effective option for all types of acne scarring with minimal complications, especially in skin of color.[2,4–9] Multiple studies have demonstrated its efficacy and safety for moderate to severe acne scarring.[7,8] FRM treatment led to significant improvements in acne scar grading, with 80.64% of patients showing a two-grade improvement in one study. The technique also reduced inflammatory and non-inflammatory acne lesions, sebum excretion, and improved overall skin texture.

Fractional Radiofrequency Microneedling (FRM) has shown promising results in treating acne scars and large facial pores.[7,8] These improvements are attributed to dermal matrix regeneration. Adverse effects were generally mild and transient, including erythema, edema, and temporary hyperpigmentation. While FRM has demonstrated effectiveness as, evidence comparing it to combination therapies or fractional laser treatments remains inconsistent.

Therefore, we aimed to systematically evaluate the current literature on the efficacy of FRM as a monotherapy to treat different types of facial acne scarring.

Materials and Methods

Methods

The PubMed and EBSCO databases were comprehensively searched from inception to July 2024 to identify studies using the following terms: "radiofrequency", "fractional radiofrequency", "microneedling", "acne scar", and "acne scarring". All randomized and non-randomized trials, cohort studies, and large case series published in English were reviewed (Table 1).

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Table 1 Summary of Study Characteristics

Title	Sample Size	Study Design	Skin Type	Intervention Groups	Control Group	FRM Parameters	Scales	Results	Adverse Effects
Emam et al[1]	21	Randomized split-face, single-blinded clinical trial	II–IV	FRM	Fractional Er:YAG laser	- **Depth**: 2.5 mm (cheek and chin) and 0.8 mm (forehead and nose) - **Pulse width**: 600 ms - **Power**: level 6 and 2 MHz	- GBQLS	- GBQLS for the FRM group: pre-treatment score (18.14) versus post-treatment score (12.05). - GBQLS for the laser group: pre-treatment score (19.33) versus post-treatment score (13.19).	- Eczematization (laser side only) - PIH (laser side only) - Pain - Erythema - Folliculitis (FRM side only) - Mild post-treatment heat
Fusano et al[10]	11	Prospective study	N/A	FRM	N/A	- **Depth**: 2 mm (1st pass) and 1 mm (2nd pass) - **Pulse width**: 200 ms (1st pass) and 100 ms (2nd pass) - **Power**: 30–60%	- GBS - GAIS	- GAIS revealed 36.6% of patients very much improved, 45.6% much improved, and 18.1% improved.	N/A
Sirithanabadeekul et al[4]	24	Single-center, prospective, evaluator-blinded trial	III–V	FRM	N/A	- **Depth**: 3+ mm - **Pulse width**: N/A - **Power**: 30–35 mJ/pin	- ECCA - GBQLS - Acne Scar Volume Measurement	- ECCA score: 25.9% decrease from baseline after the 12th week and 33.88% decrease after the 20th week. - GBQLS: 33% had a one grade improvement after 3 months; 3 of these patients had a change from moderate to mild and 5 had a change from severe to moderate. - Acne scar volume showed a significant decrease of 29.26% after 20 weeks.	- PIH - Pain - Erythema - Edema - Swelling - Burning sensation - Mild acne eruption
Pallb et al[11]	32	Single-center, prospective, self-controlled clinical study	III–V	FRM	N/A	- **Depth**: 2 mm (cheek) and 1.5 mm (forehead) - **Pulse Width**: 10 or 20 ms - **Power**: 12 W	- GBQLS - GBQNS - IGA	- Mean GBQLS score pre-treatment was 2.91 and post-treatment was 1.69. - Mean GBQNS decreased from 17.16 pre-treatment to 7.03 after treatment. - IGA: 40–80% improvement with a mean of 58.44%.	- Pain - Erythema - Swelling - Spot bleeding

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Pudukadan et al[12]	19	Prospective study	III–V	FRM	N/A	**- Depth**: 2.0–3.0 mm **- Pulse width**: 110–140 ms **- Power**: 15–25 W	- GBQLS	- At least one acne scar grade improvement noted in 11 of 19 patients (57.9%) after 1 month and in 9 of 9 patients (100%) after 3 months.	- PIH - Erythema - Edema - Micro crusting
Park et al[13]	20	Prospective, blinded study	III–IV	FRM	N/A	**- Depth**: 1.5 mm **- Pulse width**: 50 ms **- Power**: 17.5 W	- Objective clinical assessments by dermatologists - Subject's Global Assessment	- All patients had two or more grade improvements by physicians; - Subject's Global Assessment: 7 patients (35%) experienced an enhancement to grade 4, 8 patients (40%) reported an improvement to grade 3, and 5 patients (25%) described clinical advancements corresponding to grade 2.	- PIH -Acne worsening - Pain - Erythema - Flushing - Crusting - Oozing
Chae et al[14]	40	Randomized, controlled, single-blinded study	III–V	FRM	Fractional Er:Glass laser	**- Depth**: 2 mm **- Pulse width**: 0.1 ms **- Power**: 40–60 W (max 80 W)	- ECCA - PGA	- In the laser group, the mean ECCA score reduced from 74.25 to 55.5. In the FRM group, the mean ECCA score decreased from 68.75 to 56.0. - PGA: In the laser group, clinical improvements were good in 8 patients, and excellent in 3 patients. In the FRM group, the improvement was good in 7 patients, and excellent in 1 patient.	- PIH - Pain - Erythema - Swelling - Edema - Dryness - Acne
Min et al[5]	20	Prospective, single-blind, randomized, and comparative clinical trial with a split-face manner	III–IV	FRM	BR	**- Depth**: N/A **- Pulse width**: 50–70 ms **- Power**: 5.0–7.5 W	- ECCA - IGA	- ECCA: FRM group: Pre-score 124.06, Post-score 104.06; BR group: Pre-score 124.38, Post-score 116.88. - Mean IGA showed that FRM and BR treatment resulted in 50% and 25% improvements, respectively.	- Pain - Erythema - Oozing - Swelling - Edema
Thi et al[14]	52	Prospective study	III–V	FRM	N/A	**- Depth**: N/A **- Pulse width**: N/A **- Power**: N/A	- GBQLS - GBQNS	- GBQNS scores decreased from 16 to 5.6. - GBQLS scores show that grade 4 scars decreased from 71.2% to 25%.	- PIH

(*Continued*)

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Table 1 (Continued).

Title	Sample Size	Study Design	Skin Type	Intervention Groups	Control Group	FRM Parameters	Scales	Results	Adverse Effects
Lan et al[15]	60	Randomized split-face study	III–IV	FRM	Fractional micro-plasma RF	- **Depth**: 1.5–2.5 mm (max 3.5 mm) - **Pulse width**: 80–140 ms (max 200 ms) - **Power**: 10–15 W (max 25 W)	- ECCA	- Mean decrease in ECCA scores from the baseline was significantly more pronounced in fractional micro-plasma radiofrequency as compared with FRM (41.33 vs 32.17). - ECCA scores reduced from 95.42 to 54.33 on the fractional micro-plasma RF side. - ECCA scores reduced from 92.17 to 60.25 on the FRM side.	- PIH - Pain - Erythema - Swelling
Huang et al[16]	40	Retrospective study	III–IV	FRM	N/A	- **Depth**: cheeks: 1.6 mm, nose: 1.8 mm, forehead: 1 mm, lower jaw: 1.4 mm, periocular: 0.8 mm - **Pulse width**: 400–600 ms - **Power**: 5–6 W	ECCA	- Mean ECCA score decreased from 40 to 12 at the last visit.	- Transient track marks - Perioral herpes simplex - Mild and transient pain and erythema
Hendel et al[9]	15	Randomized comparative trial, split-face single-blinded	II–III	FRM	AFL:CO2	- **Depth**: 3–1 mm - **Pulse width**: N/A - **Power**: 30–98 mJ/pin (460 kHz)	- Clinical improvement of scar texture (0–10 scale)	AFL and FRM were equally effective in skin texture after 3 months.	Pain
Chowdhary et al[6]	40	Randomized comparative trails	III–V	FRM	FRM+PRP	- **Depth**: 1.5–3.5 mm - **Pulse width**: N/A - **Power**: 25–45 W	- GBQLS - GBQNS	GBQNS score: 73% of patients in the FRM+PRP group and 62% of patients in the FRM only group had a good response.	- Edema - Erythema - Transient PIH
Vejjabhinanta et al[2]	26	Single-blinded trails	IV–V	FRM	N/A	- **Depth**: 1.5 mm - **Pulse width**: 330 ms - **Power**: 30 W	- Subjective evaluation by dermatologists	The maximum improvement was seen at 6 months follow-up. Improvement of the patients' scars was excellent in 8%, good in 23%, fair in 36.5%, and slightly improved in 32.5%.	- PIH - Erythema - Edema - Thin scabs

Cho et al[7]	30	Prospective	Mild-to-moderate facial acne scars	FRM	N/A	**- Depth**: 1.5 mm **- Pulse width**: 0.2 s **- Power**: 500–700 W	- IGA	Acne scars: improved in 22 patients (73.3%). One patient improved two grades from baseline, and 21 improved one grade.	- Pain - Erythema
Chandrashekar et al[8]	31	Retrospective study	III–V	FRM	N/A	**- Depth**: 3.5, 2.5, 1.5 mm, respectively, on 3 passes. 1.5 mm on forehead, temple, and bony prominences **- Pulse width**: 10–1000 ms **- Power**: 35–40 W	- GBQLS - GBQNS	Grade 4: 80.64% showed improvement by 2 grades and 19.35% showed improvement by 1 grade. Grade 3: 76.47% improved by 2 grades, and 23.52% showed improvement by 1 grade. Quantitative assessment showed that 58% of the patients had moderate, 29% had minimal, 9% had good, and 3% showed very good improvement.	- PIH - Track marks - Pain - Erythema - Edema

Abbreviations: FRM, fractional radiofrequency microneedling; GBQLS, Goodman and Baron's Qualitative Scale; GBS, Goodman and Baron Scale; PIH, post-inflammatory hyperpigmentation; GAIS, Global Aesthetic Improvement Scale; ECCA, Échelle d'Évaluation Clinique des Cicatrices d'Acné; GBQNS, Goodman and Baron's Quantitative Scale; IGA, Investigator's Global Assessment; BR, bipolar radiofrequency; PGA, Physician's Global Assessment; AFL:CO2, ablative fractional CO2 laser; PRP, platelet-rich plasma.

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The titles, abstracts, author names, journal names, and publication years of the identified records were exported to an MS Excel spreadsheet (Microsoft Corp. Washington, USA). Two independent reviewers (G.N., H.A.) screened the titles and abstracts of the collected studies and independently performed eligibility assessments by carefully screening the full text of the selected papers. This systematic review was conducted following the reporting checklist of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart (Figure 1).

Study Selection

The inclusion criteria were as follows: original studies (randomized controlled trials [RCTs], cohort studies, case–control studies, and case series); studies published in English; studies with at least 10 participants 15 years and older; and studies without restrictions on the delivery mode for the fractional radiofrequency, sex, or race of the patients. We excluded papers unavailable for review and those that used FRM combined with other treatment modalities for acne scarring (Figure 1).

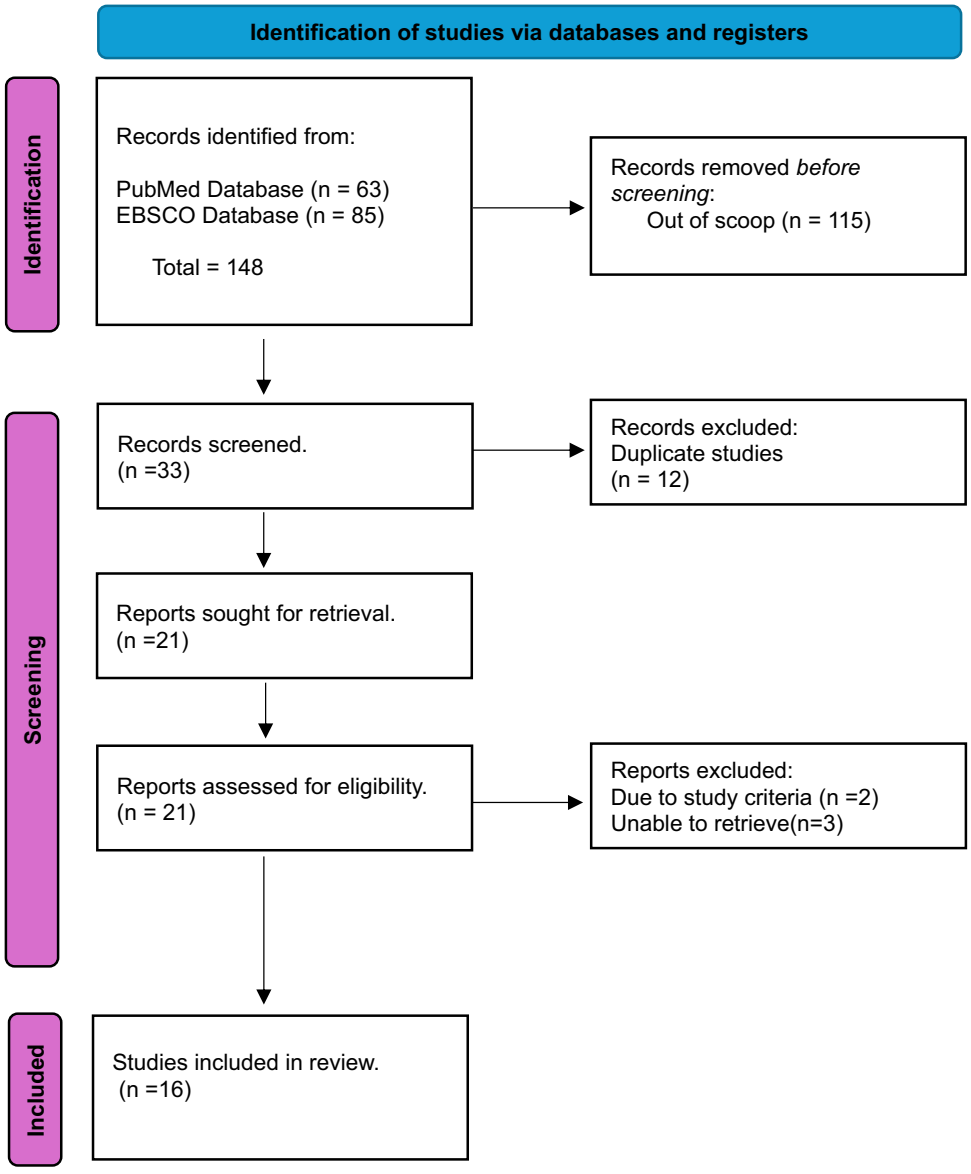

Figure 1 Flowchart of literature identification, screening, eligibility, and inclusion process.
Notes: PRIMSA figure adapted from Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. Creative Commons.[18]

Quality Assessment

RCTs were assessed using the Cochrane risk-of-bias tool. For cohort studies, we implemented the risk-of-bias criteria suggested by the Newcastle-Ottawa Scale. Two reviewers independently assessed the methodological quality of each study (G.N., H.A.). Disagreements were resolved by discussion and consensus.

Results

The initial screening identified 63 and 85 articles in the PubMed and EBSCO databases, respectively. After applying our criteria, 32 studies were reviewed; one was excluded because of the study criteria, another was excluded because it focused on treating acne vulgaris, and three could not be retrieved. 16 articles were included after removing 12 duplicate studies.

Study Design

The main characteristics of the 16 identified articles are shown in Table 1. This systematic review included 481 patients. The included articles comprised six prospective studies, six RCTs, three retrospective studies, and one comparative trial. Most studies had a follow-up between one and six months after the last treatment (Table 1). These studies offered a more accurate representation of FRM as a treatment option because FRM was tested under various conditions using different study designs.

Efficacy

10 of the included studies compared FRM as a monotherapy for acne scarring with controls. Conversely, 6 studies compared FRM to another treatment modality. For instance, Emam et al compared the efficacy of FRM to fractional ablative Er:YAG laser; their results suggested that both treatment options improved acne scars without significant differences between the two treatment options.[1] However, the fractional Er:Glass laser was marginally more effective, while FRM showed good adherence and short downtime.[16] Min et al compared FRM with bipolar radiofrequency (BR), revealing that FRM was more effective in treating acne and acne scars.[5]

Hendel et al compared FRM with an ablative fractional CO_2 laser and showed that both treatment options were equally effective. However, ablative fractional CO_2 laser treatment led to more pronounced local skin reactions, whereas FRM was more painful.[9] Chowdhary et al compared FRM to combined FRM and platelet-rich plasma (PRP). The results of the Goodman and Baron Scale (GBS) and observer scar assessments showed that both treatments were equally effective. However, the results of the Dermatology Life Quality Index (DLQI) and overall scar assessments were better in the combination group than in the FRM group alone.[6] Similarly, clinical improvements in patients showed that Microplasma Radiofrequency was more effective. Nonetheless, while Microplasma Radiofrequency was more painful, FRM had fewer side effects and shorter downtime.[10]

Patient Satisfaction

Various scoring systems have been used to assess patient satisfaction with FRM. For example, Hendel et al showed moderate-to-high satisfaction with FRM compared with ablative fractional CO_2 laser treatment.[9] Conversely, a study comparing FMR and BR found that patient satisfaction scores were higher in the BR group than in the FMR group immediately after treatment on day 1. However, higher scores were reported for FMR than BR on days 7 and 84.[5] Additionally, many patients in the FRM group reported high satisfaction rates (26–89%).[7,11,13] In one study, almost half of the participants reported excellent improvement in acne scarring even at the three-month follow-up.[4] Finally, one study reported a high satisfaction rate of 89% after three months of follow-up from the last FRM session.[16]

Further studies explored patient satisfaction by observing improvement using a subjective global assessment. Two studies had similar results, revealing that 36.6% and 35% of patients were significantly improved, 45.6% and 40% were much improved, and 18.1% and 25% were improved, respectively.[10,13] Additionally, one study reflected participants' satisfaction with improvement in their acne scars. The percentage improvement ranged from 30% to 90%, with a mean of 62.50%.[11]

FRM treatment for acne scarring positively affected patients' psychosocial well-being and overall quality of life. In 40 participants, DLQI scores improved drastically from the baseline of their initial assessment by using FRM + PRP, showing statistical significance ($p < 0.001$) toward a better quality of life after the fourth session.[6] Another study assessed the impact of acne scars on quality of life and demonstrated significant improvements in participant quality of life following treatment. Participants were less upset by negative comments, no longer avoided socializing with friends or family, and were less bothered by their scars, which positively impacted relationships ($p < 0.001$).[1]

Quality Assessment

The quality of the studies was assessed using the Cochrane risk-of-bias tool 2 in (Figure 2) for RCTs and the modified Newcastle-Ottawa Scale for non-randomized trials (Table 2). The study conducted by Chowdhary et al demonstrated concerns for bias in multiple domains of the study methodology, which could affect the validity of the results. In contrast, the other included RCTs were mostly of high quality, with some concerns about the Emam et al and Chae et al studies. By omitting the nonexposed cohort and the comparability components, modifications were made based on the Newcastle-Ottawa Scale for the non-randomized trials. The total points are 6 lowering the cutoff to 5 for good quality, 4 for fair quality, and 2 for poor quality. The study by Thi et al was deemed to be of poor quality in the cutoff of the scale because of the lack of ascertainment of exposure and inability to demonstrate the outcome of interest at the beginning of the study and outcome assessment (Table 2).

Adverse Effects

In our systematic review, the most frequently reported adverse effect from FRM treatment was erythema, typically transient and resolving within hours to a few days. While the extent and duration of erythema may vary, a study by Cho et al reported the longest duration of transient erythema averaged 7.8 ± 2.6 days.[7] Other adverse effects such as pain,

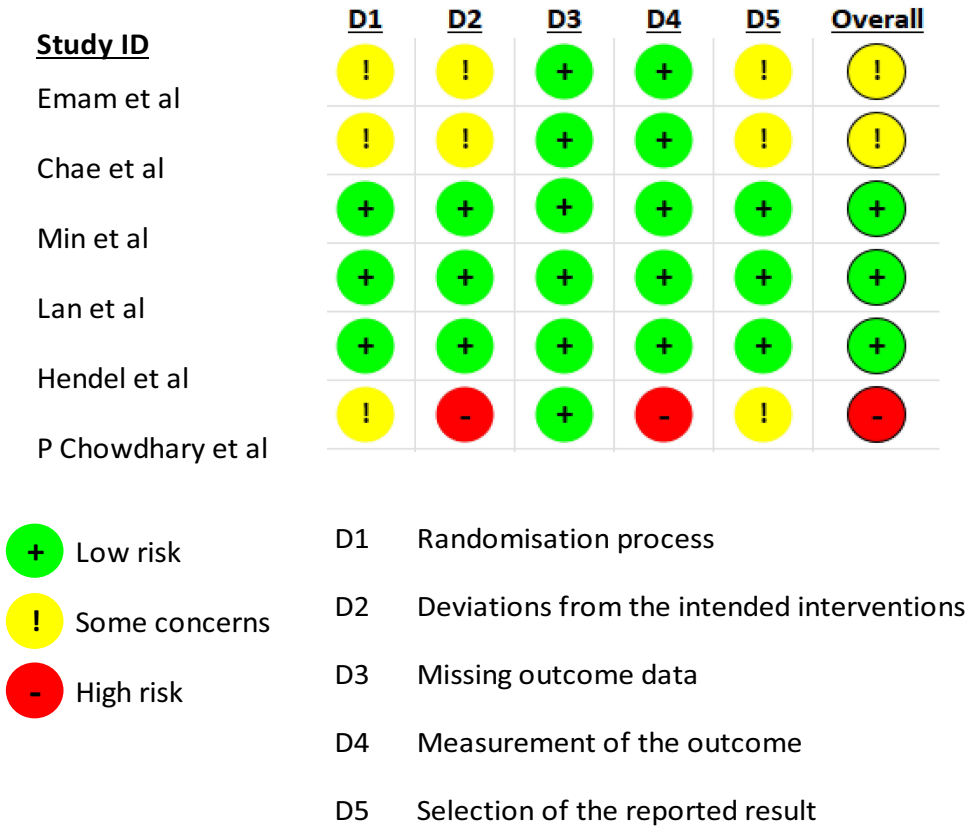

Figure 2 Risk of bias summary for included RCTs.

Table 2 Assessment of the Quality of the Included Non-Randomized Trials

Non Randomized Clinical Studies							
	Selection			Outcome			Quality Score
First Author	Representativeness of the Exposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest was not Present at Start of Study	Assessment of Outcome	Was Follow-up Long Enough for Outcomes to Occur	Adequacy of Follow up of Cohort	
Fusano et al[10]		*	*	*	*	*	5
Sirithanabadeekul et al[4]		*	*	*	*	*	5
Pall et al[11]		*	*	*	*	*	5
Pudukadan et al[12]		*	*		*	*	4
Park et al[13]		*	*	*	*	*	5
Thi et al[14]					*	*	2
Huang et al[16]		*	*	*	*	*	5
Vejjabhinanta et al[2]		*	*	*	*	*	5
Cho et al[7]		*	*	*	*	*	5
Chandrashekar et al[8]		*	*		*	*	4

Note: * Means 1 Point in the Total Quality Scoring.

edema, scaling, crusting, oozing, swelling, and flushing were also reported.[1,2,4–6,8,9,11–13,16] Less frequently reported side effects included folliculitis, burning sensation, bleeding spots, mild acne eruptions, acne vulgaris, and dryness. These adverse effects were generally temporary.[1,4,11,17]

Major adverse effects, although rare, were also reported. Track marks, relatively uncommon, were observed in only two patients among the studies reviewed. One patient experienced worsening acne, whereas another experienced aggravated inflammatory acne lesions.[13] In addition, one patient developed a flare of perioral herpes labialis.[16]

Post-inflammatory hyperpigmentation (PIH) was reported in seven studies. All reported PIH cases were typically temporary and subsided during follow-up.[2,4,6,8,12,13,17] Five studies focused on individuals with skin types III–V reported PIH incidence.[4,6,12,13,17] Conversely, one study involving 32 patients with skin types III–V did not report PIH.[11]

Most studies mentioned that pain was reported as a common minor side effect of treatment; however, only eight studies evaluated pain using the Visual Analog Scale. The pain score ranged from three to five.[4,5,11,16,17] The mean pain score of the included participants was 5.655, reflecting mild-to-moderate pain that was transient and subsided within 24 h.

Discussion

Our systematic review evaluated all currently available studies published in selected databases that examined the efficacy and safety of FRM for treating acne scarring. All included studies showed significant improvement in acne scarring after using FRM as a monotherapy (Table 1).[1,2,4–17] These findings support the addition of FRM as a safe and effective method for treating acne scarring as a single treatment modality or combined with other treatment options.[6] In comparative studies with other acne scar treatment modalities, such as 1550 Er:Glass and fractional ablative CO_2 lasers, FRM showed similar efficacy.[9,16] The same studies reported that the FRM procedure could be more easily tolerated and showed shorter downtime with fewer side effects.[9,16] In another split-face comparative study, FRM and fractional ablative Er:YAG laser improved acne scarring after four sessions with no significant difference on either side.[1]

Based on our systematic review, most participants undergoing FRM treatment had skin of color III to V, although two studies did not report the Fitzpatrick skin type.[7,10] None of the patients in our review fell into the type I or VI extremes;

the participants had skin types ranging from types II to V. Despite this, few studies reported PIH as a complication after FRM, which mostly resolves during the follow-up period. Therefore, FRM may be considered safer for treating acne scarring in darker skin types.

Although FRM showed significant improvement in all atrophic scar types, multiple studies have shown variations in response to different scar types.[1,5,8,16] In the study by Huang et al, M-shaped scars exhibited the fastest response to FRM,[16] which could be explained by varying depths of the different types of acne scarring.[6] FRM also showed superior results in some acne scar types, such as Icepick and Boxcar scars, compared with the BR treatment.[5]

To the best of our knowledge, this is the first systematic review to analyze FRM as a monotherapy for acne scar treatment. The main limitation of this study was the inability to conduct a meta-analysis because of variations in scoring systems (Table 1). Another limitation was that none of the studies reported participants with skin type VI; thus, the reported efficacy and adverse effect profile might differ in this group. Finally, the follow-up period of the included studies was only up to six months; longer follow-up periods might show different treatment outcomes due to the lengthy neocollagenesis process. Larger, well-designed RCTs with longer follow-up periods are needed to establish accurate settings for FRM in acne scar treatment.

FRM might be considered as an effective and safe treatment as a monotherapy for acne scarring despite some of its temporary adverse effects. Several treatment settings have been proposed. The lack of a standardized FRM treatment approach necessitates RCTs with objective measurements and longer follow-ups to establish a safe and effective treatment protocol.

Data Sharing Statement

The data supporting the findings of this study can be obtained from the corresponding author.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare no conflicts of interest.

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