Received: 4 February 2022 | Revised: 26 April 2022 | Accepted: 26 May 2022

DOI: 10.1111/jocd.15137

JCD Journal of Cosmetic Dermatology WILEY

ORIGINAL ARTICLE

A novel technique in reducing sebum production and improving atrophic acne scars

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Abstract

Objective: Fractional microneedling radiofrequency (FMR) has gained popularity for the treatment of acne scars, owing to favorable outcomes and short downtimes. This study aimed to investigate FMR use in reducing facial sebum production and treating acne scars.

Materials and Methods: This single-center, prospective, evaluator-blinded trial compared sebum production after three sessions of FMR (Fractora® 24-pin coated tip) performed one-month apart. Results were evaluated with a sebumeter (Cutometer®), sebaceous gland histology, and subjects' assessment. Acne scars were graded according to the Echelle d'Evaluation clinique des Cicatrices d'acné scale, Goodman and Baron's qualitative grading system, acne scar volume measurement, and subjects' assessments.

Results: Sebumeter results revealed a significantly decreased ($p < 0.05$) sebum production since the first treatment, sustained throughout the study period. Histological assessment showed decreased density and size of sebaceous glands. The mean acne scar volume decreased significantly, without a significant increase in the mean melanin levels.

Conclusion: Fractora® 24-pin coated tip can be used as an alternative for patients with acne scars, who wish to concomitantly reduce their facial oiliness. A significant decrease in facial oiliness and acne scars' volume can be seen after a single treatment session, with up to 15.48% decrease in facial oil production.

KEYWORDS
acne scars, facial oiliness, fractional microneedling radiofrequency, sebum reduction

1 | INTRODUCTION

Acne is one of the most common skin diseases, approximately 650 million of the world's population are affected by acne.[1] It is a chronic inflammatory disease of the pilosebaceous unit with a high lifetime prevalence and is known to negatively affect the quality of life.[2,3]

Of the variants of acne, inflammatory acne in particular can lead to permanent acne scars. Scar severity may result from the delayed timing of treatment.[4] In one study, approximately 1% of a cohort of 2000 volunteers aged between 18 and 70 years had acne scars. Moreover, atrophic acne scars are reportedly three times more prevalent than hypertrophic scars and keloids.[5]

Currently, there are several methods available for treating acne scars, including ablative lasers, that often require a longer recovery time and can potentially result in post-inflammatory hyperpigmentation.[6,7] Recently, a newer technique with lesser downtime and fewer side effects, namely fractional microneedling radiofrequency (FMR), has been developed as an alternate method for treating acne scars. It does not cause direct damage to the epidermis[8] but creates radiofrequency thermal zones, damaging only the reticular dermis and

leaving minimal damage to the epidermis. By damaging the reticular dermis, it results in dermal remodeling, neoelastogenesis, neocollagenesis, and finally dermal thickening.[9] There have also been studies suggesting that bipolar radiofrequency devices are effective in reducing sweat production in patients with primary axillary hyperhidrosis.[10,11]

Compared with the 60-pin tip, a 24-pin tip has longer needles and consequently penetrates deeper, thereby affecting deeper structures such as the reticular dermis, sweat glands, and sebaceous glands better.

Therefore, this is the first study that use fractional microneedling radiofrequency 24-pin tip to evaluate both facial sebum production and improvement in acne scars concomitantly as primary and secondary outcomes, respectively. Furthermore, the histological change in sebaceous glands after three sessions of bipolar radiofrequency (RF) treatment was also evaluated.

2 | MATERIALS AND METHODS

Patients who met the inclusion criteria were enrolled from the Benchakitti Hospital. The sample size was calculated, and total of 29 healthy subjects were enrolled. The inclusion criteria are aged >18 years old, skin phototypes III–V and mild-to-severe acne scars of used Goodman and Baron's qualitative scarring grading system.[12]

The exclusion criteria are pregnancy, history of facial hypertrophic scars or keloids, history of herpes infection, active acne/infection/dermatitis/malignancy over the treatment area, history of use of contraceptive pills/injections, spironolactone, or 5α-reductase inhibitors within the last 1 month, oral retinoids within the last 6 months, or radiofrequency/laser skin resurfacing treatments in the 3 months prior to the study.

The study protocol was approved by the Human Ethics committee of the Thammasat University and was conducted in accordance with the Declaration of Helsinki (2013). Written informed consent was obtained from all participants prior to study enrolment.

2.1 | Treatment

The subjects were applied with a topical anesthetic cream on both cheeks for 45 min. The 24-pin Fractora® coated RF tips with 3000 microns pin length, and 3+ mm ablation depth was used for the treatment. The 24-pin coated tips were cleaned with 70% alcohol before the start of each treatment session. Treatment sessions were held thrice, 1 month apart. Patients were then followed up at 1 month (12th week) and 3 months (20th week) after the completion of treatment. An energy level of 30–35 mJ/pin was applied (30 mJ for skin types IV and V, and 35 mJ for skin type III). One to two passes were applied on the same area of both cheeks. The endpoints were minimal to substantial erythema and edema, or visible ablative craters. The subjects' faces were cooled with ice bags for 10 min to reduce discomfort. Then, a hydrophilic cream base was applied. They were advised to refrain from washing their faces for 24 h following the treatment and to avoid applying any make-up for at least 1 week thereafter.

Routine skincare products were prohibited 1 week prior to the study. A hydrophilic cream base was the only skincare product allowed to be used throughout the study. Other new topical medications were also prohibited. Sun avoidance and sunscreen were recommended throughout the study period.

2.2 | Evaluation

Acne scar improvement was evaluated by clinical photographs, which were taken using Olympus® OMD (Olympus Corporation) and Antera® 3D cameras (Miravex Limited Dublin) at every visit (baseline, 4th, 8th, 12th, and 20th week). They were taken in the full front, right side 90/45°, and left side 90/45° views of the face. Two blinded dermatologists assessed the clinical photographs at every visit according to the Echelle d'Evaluation clinique des Cicatrices d'acné (ECCA) scale (from a photograph) and the Goodman and Baron's qualitative scarring grading system. Furthermore, the atrophic acne scar volume and mean melanin level were also evaluated using the Antera® 3D camera at every visit. Sebum production was also measured on both cheeks using a sebumeter (Cutometer® dual MPA 580, Courage+Khazaka electronic GmbH Cologne). The subjects cleaned their faces with Physiogel Dermo-cleanser (Stiefel, a GSK Company) and stayed in a room with a temperature between 21.5 ± 2.5°C for 45 min prior to measurement.

Two subjects (Patients A and B) were injected with 1% lidocaine with adrenaline and a three-millimeter punch biopsy was performed on a boxcar scar on the cheek at baseline. Furthermore, they both underwent a second biopsy near the previous site on the 12th and 20th week, respectively. The biopsy specimen was fixed in 10%-buffered formalin and stained using haematoxylin and eosin. The lesion was sutured with 6–0 nylon. They were advised to avoid water for the first 24 h after biopsy. A topical antibiotic ointment was prescribed for 1 week. After a week, the subjects were followed up and had their sutures removed.

Additionally, they were asked to fill in evaluation forms in the first and third months post-treatment completion. They were asked about changes in acne scars and facial oiliness, evaluated using a five-point rating scale: Acne scar: 0 = No changes (0%), 1 = Slightly improved (1%–25%), 2 = Moderately improved (26%–50%), 3 = Good improvement (51%–75%), 4 = Excellently improved (76%–100%); Facial oiliness: 0 = No changes (0%), 1 = Slightly decreased (1%–25%), 2 = Moderately decreased (26%–50%), 3 = Significantly decreased (51%–75%), 4 = Excellently decreased (76%–100%).

2.3 | Statistical analysis

The data were analyzed using SPSS program (paired *T*-test and repeated ANOVA), with significant level at p-value < 0.05.

3 | RESULTS

3.1 | Demographic data

Twenty-nine patients who met the inclusion criteria were analyzed. At the end of the study period, twenty-four patients completed the study. Two patients were excluded for failing to keep-up with the treatment schedule, while three were lost to follow-up.

Fifteen men and nine women, with a mean age of 32.54 ± 4.83 years completed the study. Of them, 11 had Fitzpatrick skin type III, 12 had type IV, and one had type V. The number of patients graded as mild, moderate, and severe according to the Goodman and Baron's qualitative scarring grading system at baseline was 4, 6, and 14, respectively. The mean baseline ECCA score was 109.79 ± 24.47. The mean acne scar volume and mean melanin level calculated from the Antera 3D camera were 13.84 ± 6.87 mm^3 and 0.53 ± 0.08 mm^3, respectively. The mean sebum level calculated from the sebumeter was 54.35 ± 33.58 $\mu g/cm^2$. The baseline characteristics of the study population are shown in Table 1.

3.2 | Sebum production

The sebumeter results showed that the mean sebum production significantly decreased since the first treatment and continued to do so throughout the study period ($p < 0.05$). At 1 month after treatment completion, the mean sebum production level significantly fell by 18.28% from the baseline (from 54.35 ± 33.58 $\mu g/cm^2$ to 41.79 ± 25.64 $\mu g/cm^2$ ($p = 0.003$) and continued to fall until the study's completion with a net decrease of 20.64% from the baseline (54.35 ± 33.58 $\mu g/cm^2$ to 40.67 ± 27.57 $\mu g/cm^2$ ($p = 0.016$) (Figure 1).

Most patients reported moderate-to-excellent improvement at the 1-month and 3-month follow-up periods. Their detailed responses are presented in Figure 2.

TABLE 1 Baseline characteristics of patients

	Total ($N = 24$)
Age, years	
Mean	32.54 ± 4.83
Min	25
Max	48
Sex, *n* (%)	
Male	15 (62.5%)
Female	9 (37.5%)
Fitzpatrick skin type, *n* (%)	
III	11 (45.83%)
IV	12 (50%)
V	1 (4.17%)
Goodman and Baron's qualitative grading, *n* (%)	
Mild	4 (16.67%)
Moderate	6 (25%)
Severe	14 (58.33%)
Mean ECCA score	109.79 ± 24.47
Mean acne scars volume, mm^3	13.84 ± 6.87
Mean melanin level, mm^3	0.53 ± 0.08
Mean sebum production level, $\mu g/cm^2$	54.35 ± 33.58

3.3 | Acne scars

The mean acne scar volume was calculated using the Antera® 3D camera. The acne scar volume significantly reduced at 20th week compared with baseline ($p < 0.05$), from 13.84 ± 6.87 mm3to 9.68 ± 5.61 mm^3 (29.26% decrease). These decreases were 20.53%, 10.06%, 6.32%, and 3.05% between weeks 0–4, 4–8, 8–12, and 12–20, respectively (Figure 3). The clinical photographs from the Antera® 3D and digital cameras also showed an overall improvement in the atrophic acne scar and skin texture (Figure 4).

According to the Goodman and Baron's qualitative scarring grading system applied by two blinded dermatologists, six patients had a one grade improvement during this follow-up period, which increased to 8 patients (33%) at the three-month follow-up period (20th week). Three patients had a change in grading from moderate to mild in terms of severity, while five had a change in grading from severe-to-moderate at the end of the study (Figure 5).

The ECCA scores were provided by two blinded dermatologists based on clinical photographs at every visit. The score showed a significant decrease ($p < 0.05$) since the first treatment, with a decrease of 25.9% (109.79 ± 24.47–82.08 ± 29.08) and 33.88% (109.79 ± 24.47–73.54 ± 27.17) from the baseline to the 12th and 20th week follow-up periods, respectively (Figure 6). Most patients rated slight-to-good improvement at the 1-month and 3-month follow-up periods. None of the patients rated themselves as having no improvement in acne scars.

3.4 | Histology

The baseline biopsy was performed at the boxcar site while the follow-up one was performed near the baseline biopsy site. The biopsies were fixed in 10%-buffered formalin and stained using hematoxylin and eosin (H&E). The histology of Patient A at one-month follow-up (12th week) showed fibrosis and a decrease in size and density of the sebaceous glands (Figure 7). Patient B's histology at the three-month follow-up (20th week) showed acanthosis with an increase in fibrosis and decrease in number of sebaceous glands (Figure 8).

3.5 | Adverse effects

The average pain score during the treatment was 4.38 out of 10. Immediately after each treatment, all of the patients experienced

erythema, less than half experienced pain (20.83%), swelling (16.67%), and burning sensation (29.17%). However, these side effects disappeared within 1 week of the treatment. Seven patients experienced mild acne eruption that was completely resolved spontaneously. Although seven patients reported post-inflammatory hyperpigmentation, the mean melanin level objectively evaluated with the Antera 3D camera showed no significant increase in the mean melanin level throughout the study ($p < 0.05$).

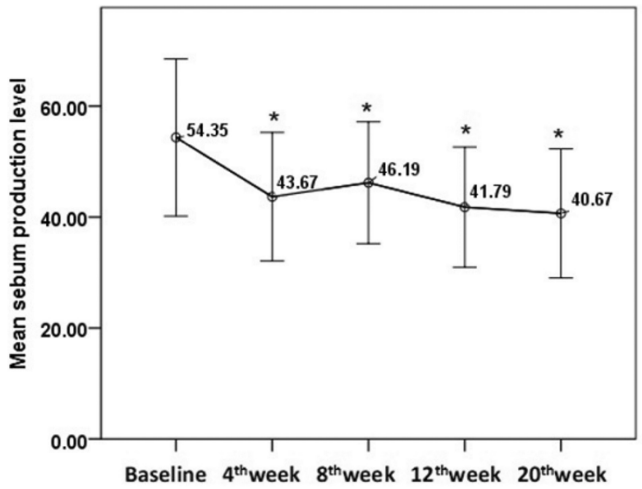

FIGURE 1 Mean sebum production level which significantly decreased from baseline since the first treatment and continued to throughout the study period ($p < 0.05$)

4 | DISCUSSION

Our results revealed that the FMR significantly reduced sebum production since the first treatment, which persisted at least 3 months after treatment completion ($p < 0.05$), similar to that demonstrated by a previous study by Kim ST et al.[13] However, the sebumeter results of the aforementioned study showed a greater decrease in mean sebum excretion 3 months after the treatment (36.99%) than our study (20.64%). This may be due to the higher number of passes performed on the patients in that study, greater density of microneedles, different company device, different weather conditions, humidity, and lastly, the difference in the study population: the study by Kim. ST et al. assessed patients with acne vulgaris, who generally have higher facial sebum levels at baseline.

In our study, the sebum production level significantly decreased since the first treatment session, and continued to decrease after treatment cessation, the improvement lasting at-least 3 months. This clinical change was also supported by the assessment of patients' facial oiliness and by histological examination, wherein a decrease in density and size of the sebaceous glands was still observed 3 months later.

This study also demonstrated better results with FMR in terms of the sebosuppressive effect than with other types of lasers. A split-face study by Jeffrey S. Orringer et al.[14] examining the efficacy of Nd:YAG in acne treatment, which also studied the sebum production levels (using Sebutape; CuDerm Corp.) revealed that there were no statistically significant differences in sebum production between treated and untreated areas at the 7th and 14th week. Another study on the

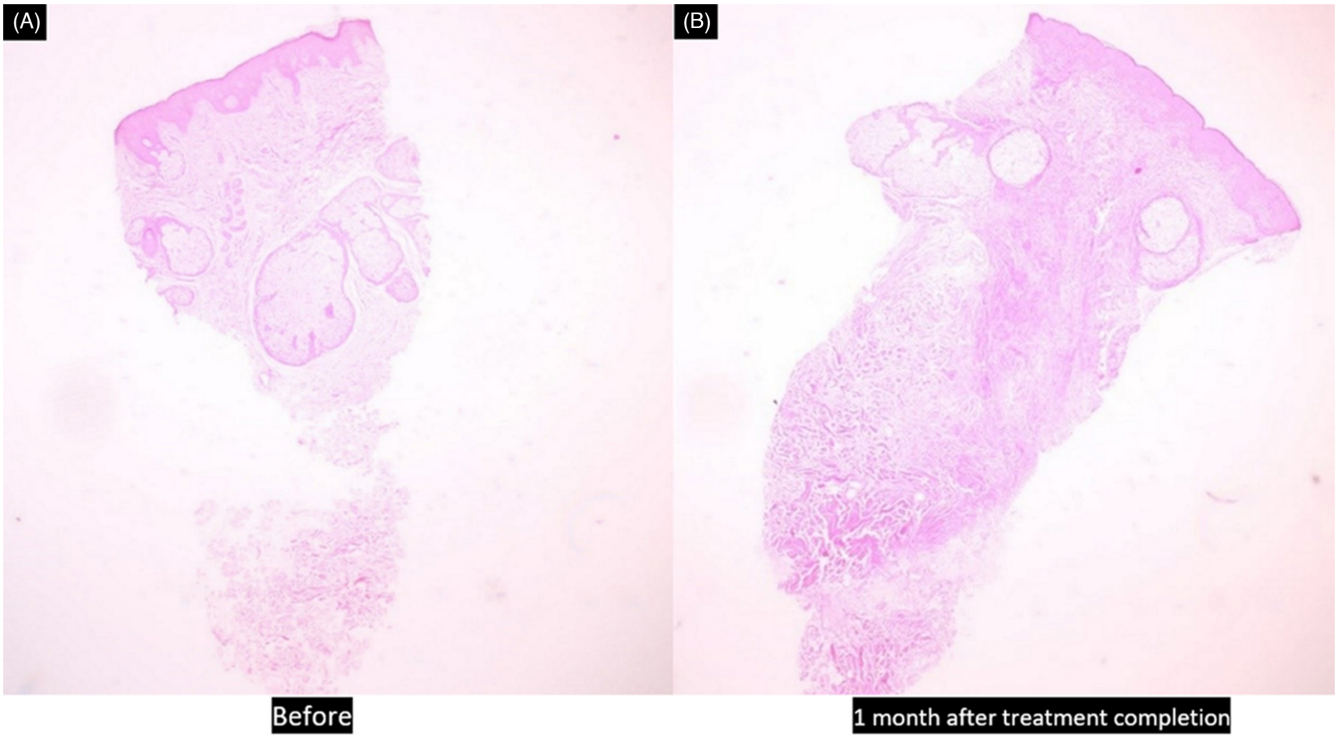

FIGURE 2 Number of patients based on changes in facial oiliness during one-month and three-month follow-up period

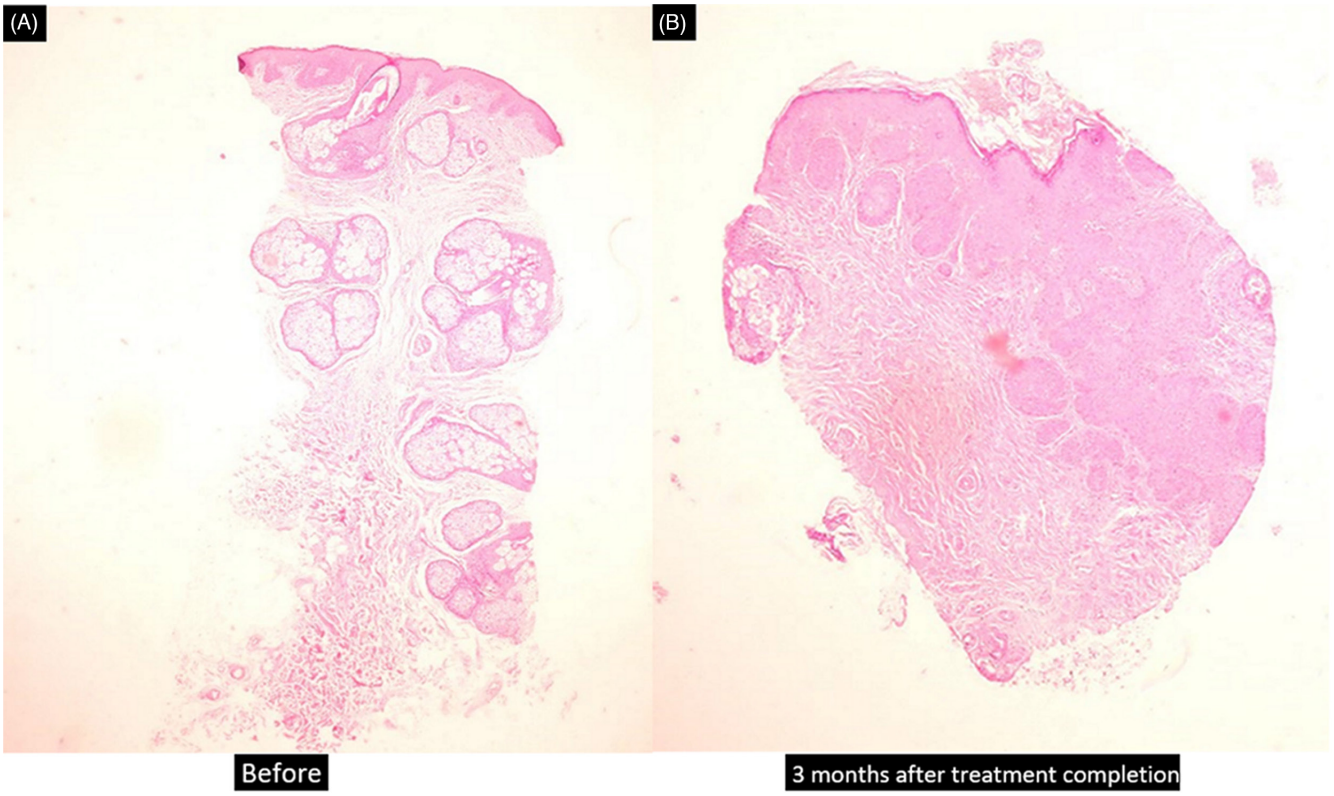

FIGURE 3 Mean acne scar volume, calculated from the Antera 3D camera. The volume significantly reduced at each follow-up period compared with baseline ($p < 0.05$)

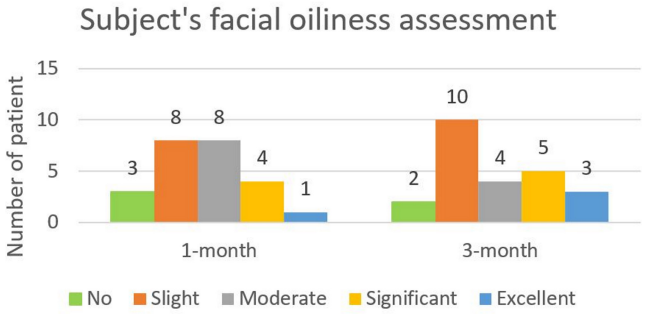

FIGURE 4 Clinical photographs from the digital (A) and Antera 3D (B and C) cameras also showed overall improvement in the atrophic acne scar and skin texture. *Depth: blue >green >yellow

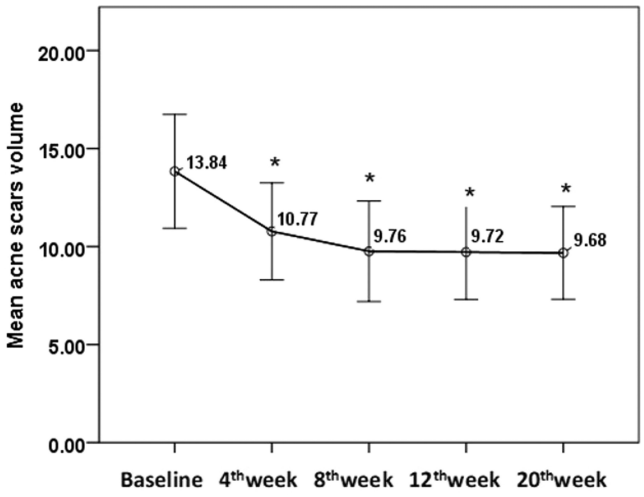

FIGURE 5 Number of patients at each visit according to the Goodman and Baron's qualitative grading applied by two blinded dermatologists

effects of a 1450 nm diode laser on facial sebum excretion rate using a sebumeter in a non-active acne patient, by Hans-Joachim Laubach et al., revealed that after three treatment sessions, there were no significant differences in changes in sebum excretion rate compared with control side at one-month follow-up period ($p > 0.05$).[15]

In our study, at 1 month after the first treatment (4th week) and 3 months after the last treatment (20th week), the mean acne scar volume calculated from the Antera® 3D camera decreased by 20.53% and 29.26%, respectively. Thus, only a single treatment session of FMR with 24-pin coated tips may be sufficient to significantly reduce the acne scar volume, although for better improvement, more sessions are recommended.

As for subjects' own evaluation of their improvement, more than 40% of the patients rated themselves as having good or excellent improvement in acne scar condition 3 months after treatment completion. Based on the Goodman and Baron's qualitative grading, one third of the patients had a one grade improvement in severity. However, this grading may not have been accurate since almost every patient came for a visit with no makeup on,

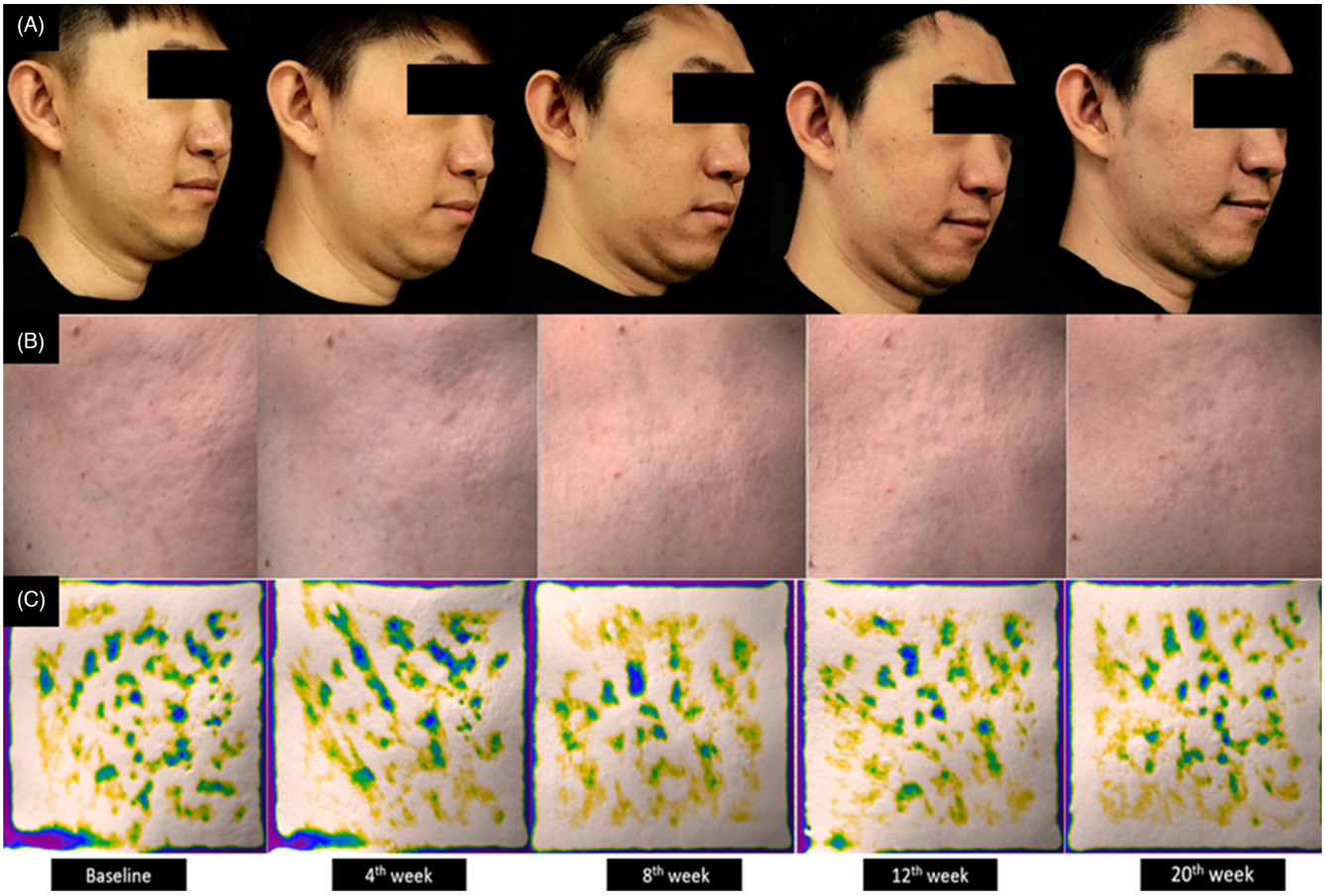

FIGURE 6 ECCA score, graded by two blinded dermatologists based on clinical photographs at every visit. The score shows a significant decrease ($p < 0.05$) from baseline since the first treatment

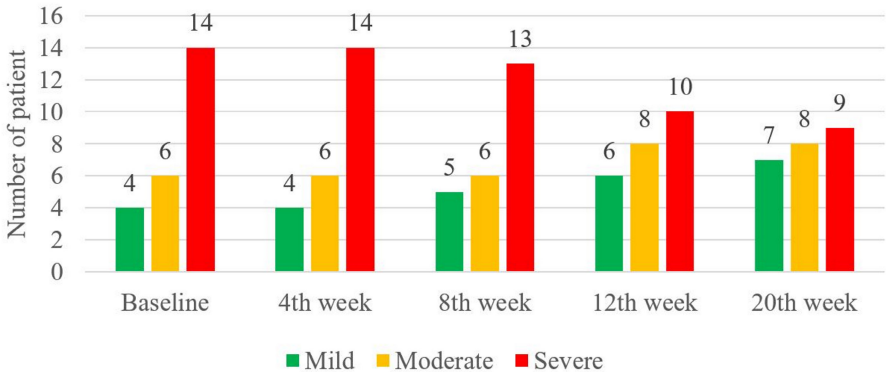

FIGURE 7 Histology of Patient A at baseline (A) and at one-month after treatment completion (B) showed fibrosis and decrease in size and density of the sebaceous glands

while the grading must be done when the patient has makeup on. Therefore, study patients should be instructed to wear makeup during the Goodman and Baron's qualitative evaluation for future studies.

Regarding the adverse effects of FMR, majority of the patients experienced erythema, while less than one-third experienced pain, swelling or burning sensation. However, these side effects disappeared or improved within 1 week after the treatment. Some claimed to have mild acne eruption that completely went away without any treatment. None of the patients had any serious side effects causing a drop-out from the study. Although seven patients claimed to have post-inflammatory hyperpigmentation, there was no significant increase in the mean melanin level throughout the study period. This may be due to the silicone coating of the 24-pin tips, which may have helped prevent direct damage to the epidermis. Nevertheless, sunscreen and sun avoidance are still recommended to patients receiving FMR treatment.

Therefore, while there are many products in the market that have a sebum-reductive property, they possess their own pros and cons. Isotretinoin is the most effective option; however, many

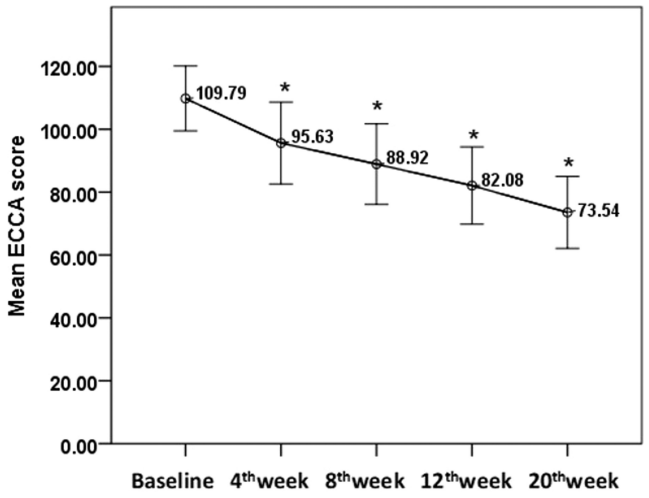

FIGURE 8 Histology of Patient B at baseline (A) and at three-month after treatment completion (B) showed acanthosis with an increase in fibrosis and decrease in number of sebaceous glands

cannot tolerate its side effects, and seek other topical options. However, the sebum-reductive property of topical products may persist only when the product is applied, unlike FMR that has a sebosuppressive effect that persists as long as 3 months after treatment completion, without causing a significant increase in the mean melanin level.

The small sample size, restriction of the follow-up period to 3 months, and the lack of comparisons with other types of pin tips are a few limitations of the current study.

Further studies on facial oiliness with longer follow-up periods will help determine the long-term or permanent results of the sebosuppressive effect of the 24-pin coated tip FMR. A study with a larger population would also provide more accurate acne scar results. Moreover, further studies to determine any difference in the sebosuppressive effect and acne scar treatment results between 24 and 60-pin tips are also recommended.

5 | CONCLUSIONS

The 24-pin coated tip FMR can be used as an alternative treatment for acne scars in patients who wish to concomitantly reduce their facial oiliness. The significant decrease in facial oiliness and acne scar volume can be seen after a single session.

AUTHOR CONTRIBUTIONS

Punyaphat Sirithanabadeekul involved in conception of framework and final approval of the version to be published. Punyaphat Sirithanabadeekul and Visanee Leetrakulwanna involved in data collection, data analysis and interpretation, and drafting the article. Punyaphat Sirithanabadeekul and Atchima Suwanchinda involved in critical revision of article.

ACKNOWLEDGMENT

The authors would like to thank to Assist. Prof. Panlop Chakkavittumrong, M.D., for reviewing histopathology.

CONFLICT OF INTEREST

The authors declare no conflicts of interest in connection with this article.

DATA AVAILABLE STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICAL APPROVAL

The study was approved by the Ethics Committee of Thammasat University (Faculty of medicine) and conducted according to the 2013 Declaration of Helsinki. All subjects provided informed consent.

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How to cite this article: Sirithanabadeekul P, Leetrakulwanna V, Suwanchinda A. A novel technique in reducing sebum production and improving atrophic acne scars. *J Cosmet Dermatol*. 2022;00:1-8. doi: 10.1111/jocd.15137