Efficacy and Safety of Continuous Water-Cooling Monopolar Radiofrequency for the Treatment of Enlarged Facial Pores and Sebum Secretion

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Abstract

Enlarged facial pores and increased sebum secretion are cosmetic concerns that can negatively affect skin texture and patient self-perception. Available treatments provide inconsistent results and may be associated with downtime or unwanted adverse effects. Continuous water-cooling monopolar radiofrequency is a non-invasive modality designed to deliver controlled dermal heating while preserving epidermal integrity. This objective of this study was to assess the clinical efficacy and safety of continuous water-cooling monopolar radiofrequency in reducing facial pore counts and sebum secretion.

This prospective cohort study included 10 participants (5 males and 5 females), aged 20–45 years, with clinically visible enlarged pores on the cheeks. All participants received two monopolar radiofrequency treatment sessions at four-week intervals. Pore counts and sebum secretion were evaluated at baseline, 1 month after the first session, and at 1 and 3 months following the second session, and treatment-related adverse events were recorded. Pore counts decreased by 13.23% after the first treatment and by 31.57% three months after the second treatment, while sebum levels decreased by 27.81% and 54.25%, respectively. Both outcomes showed progressive and statistically significant improvement during the 3-month follow-up. Treatments were well tolerated, with no serious adverse events; mild transient erythema was the most commonly reported effect. These findings indicate that continuous water-cooling monopolar radiofrequency is a safe and effective non-invasive treatment option for reducing enlarged facial pores and controlling sebum secretion. This modality may be particularly suitable for patients seeking aesthetic improvement with minimal discomfort and downtime.

Keywords: *monopolar radiofrequency, enlarged pores, sebum secretion*

1. Introduction

Enlarged facial pores and excessive sebum production are common dermatologic concerns, particularly in young and middle-aged adults (Kim et al., 2013; Lee et al., 2016; Roh et al., 2006). These features are influenced by multifactorial influences, including sebaceous gland activity, follicular architecture, skin elasticity, and genetic predisposition (Kim et al., 2013; Sugawara et al., 2019; Sugiyama-Nakagiri et al., 2008). Although not medically harmful, dilated pores often contribute to uneven skin texture and dissatisfaction with facial appearance (Bloom, 2020; Uhoda et al., 2005).

A wide range of treatment modalities such as topical agents, chemical peels, lasers, and energy-based devices have been implemented to improve these conditions. However, clinical outcomes are variable and some approaches are limited by irritation, post-inflammatory changes, or prolonged recovery periods (Endly & Miller, 2017; Grimes, 1999; Măgerușan et al., 2023; Parvar et al., 2023). As a result, there is an ongoing need for safe treatments with consistent efficacy.

Radiofrequency (RF) technology has gained attention in aesthetic dermatology because it delivers thermal energy directly to the dermis without dependence on epidermal chromophores (Jia & Feng, 2025; Shin et al., 2024; Suh et al., 2020). This mechanism induces controlled dermal heating that stimulates collagen remodeling and neocollagenesis while minimizing epidermal injury (Hwang et al., 2024; Lee et al., 2024; Wanitphakdeedecha et al., 2022). In addition to improving skin laxity, dermal heating may also influence sebaceous gland activity by inducing structural remodeling around the pilosebaceous unit and modifying sebaceous gland function. Continuous water-cooling monopolar radiofrequency further refines conventional RF technology by incorporating simultaneous epidermal cooling while maintaining sustained dermal heating. This cooling system protects the epidermis and allows the delivery of higher and more uniform thermal energy

to deeper dermal layers, thereby improving treatment tolerability and safety (Foster et al., 2021; Zelickson et al., 2004). By targeting the dermal environment surrounding the pilosebaceous unit while preserving surface integrity, this technology may contribute not only to collagen remodeling and pore tightening but also to the modulation of sebaceous gland activity, potentially leading to a reduction in sebum secretion (Jia & Feng, 2025).

Despite growing clinical use, evidence regarding the effectiveness of continuous water-cooling monopolar radiofrequency for reducing facial pore size and sebum secretion remains limited. The present study was therefore designed to prospectively evaluate the efficacy and safety of this modality in patients with enlarged facial pores (Techapichetvanich et al., 2023).

2. Objectives

1) To assess the efficacy of continuous water-cooling monopolar radiofrequency in reducing sebum excretion in the cheek area.

2) To evaluate the efficacy of continuous water-cooling monopolar radiofrequency in reducing facial pore size in the cheek area.

3) To evaluate the safety profile of continuous water-cooling monopolar radiofrequency by documenting treatment-related adverse events.

3. Materials and Methods

3.1 Study Design

This single-center prospective cohort study was conducted at a dermatology clinic affiliated with Chulabhorn International College of Medicine, Thammasat University, Thailand. The study protocol received approval from the institutional ethics committee, and written informed consent was obtained from all participants prior to enrollment.

3.2 Participants

Ten participants (5 men and 5 women) aged 20–45 years were enrolled in this study. Eligible participants were male or female individuals with clinically visible facial pores accompanied by excessive sebum production and Fitzpatrick skin types III–IV.

Exclusion criteria included the presence of active skin infections or moderate to severe acne; pregnancy or lactation; a history of photosensitivity, skin cancer, or keloid scarring; use of systemic isotretinoin within the previous six months; use of hormonal therapy within the previous three months; and any prior aesthetic treatments that could interfere with study outcomes. These included radiofrequency or other energy-based device treatments, chemical peels, botulinum toxin injections, or other anti-aging procedures in the treatment area within the past six months, as well as dermal filler injections in the treatment area within the past 12 months.

To standardize measurements, all evaluations were performed in a temperature-controlled room. Participants were instructed to cleanse their faces using the same cleanser provided by the researchers prior to assessment. After cleansing, participants rested for 15 minutes to allow acclimatization to the controlled environment before pore count and sebum measurements were performed.

3.3 Treatment Protocol

All procedures were performed by a dermatologist using a monopolar radiofrequency device equipped with a continuous water-cooling system (VOLNEWMER®, Classys Inc., Seoul, South Korea). Each participant will undergo two treatment sessions, spaced four weeks apart. Explain the application of the 3.0-cm² treatment tip on the cheeks, ensuring energy settings are adjusted to the standard protocol (level 2.5) to achieve the endpoint of mild erythema or visible pore tightening, utilizing 80-120 shots per side as needed based on the endpoint.

Additionally, outline how you will adjust the treatment for participant comfort if they report a moderate pain level (VAS 4-6), while maintaining all necessary safety parameters. Highlight the critical role of continuous water-cooling during the procedure to protect the skin from excessive heat. Finally, include any relevant observations or outcomes from the treatment sessions, detailing the effects on participants' skin.

Participants were advised to avoid topical retinoids, exfoliating agents, and anti-inflammatory medications during the study period.

3.4 Outcome Measures

Primary outcomes were changes in facial pore count and cheek sebum secretion, assessed at baseline, 1 month after the first treatment, and at 1 and 3 months following the second treatment. Facial pore count was evaluated using the TRICA 3D skin analyzer (Face3D-10, Qingdao Xiao U Technology Co., Ltd., Qingdao, China). Sebum secretion was measured using a Sebumeter® (Sebumeter SM815, Courage + Khazaka Electronic GmbH, Cologne, Germany). Measurements were obtained from both the left and right cheek at standardized locations positioned 1 cm lateral to the nasal ala. The same anatomical sites were used at every visit to ensure measurement consistency. The values obtained from both sides were averaged and used for analysis and comparison across visits. Secondary outcomes included treatment-related adverse events.

3.5 Safety Assessment

Adverse events were assessed at each visit and classified according to severity and duration, with specific attention to erythema, edema, blistering, infection, and pigmentary changes.

3.6 Statistical Analysis

Changes in pore count and sebum levels over time were analyzed using the generalized estimating equation (GEE) model to account for repeated measurements within participants. Results are reported as mean ± standard deviation, along with beta coefficients and 95% confidence intervals. Statistical significance was defined as $p < 0.05$.

4. Results and Discussion

4.1 Results

All 10 participants completed the treatment sessions and follow-up visits. The mean age was 32.5 ± 5.78 years (range 24–39). The cohort consisted of equal numbers of male and female participants, all with Fitzpatrick skin types III (80%) or IV (20%). No participant reported relevant comorbidities or current medication use.

Table 1 Demographic data (n=10)

Data	C2	Statistics data
Age	Mean ± SD.	32.5 ± 5.78
	Min - Max	24 - 39
Gender	Female	5 (12.5%)
	Male	5 (12.5%)
Comorbidity	No	0 (%)
Current medication	No	0 (0%)
Fitzpatrick	3	8 (80%)
Skin type	4	2 (20%)

The mean baseline cheek pore count was 1342 ± 344.36. A statistically significant reduction in pore count was observed at all follow-up visits. After the first treatment, the mean pore count decreased to 1166.4 ± 386.43 (mean reduction −175.6; 95% CI: –277.83 to –73.37, $p = 0.001$). Pore counts decreased by 13.23% after the first treatment compared with baseline and further declined to 30.76% after the second treatment,

reaching 31.57% three months after the second treatment. These findings indicate a progressive and sustained improvement in pore reduction over the follow-up period.

Table 2 Changes in TRICA cheek pore count from baseline at each follow-up time

Visit	Pore count cheek	Beta coefficient	95%CI.	*p*-value	% Change
1	1342 ± 344.36	Reference	-	-	-
2	1166.4 ± 386.43	-175.6	-277.83 to -73.37	0.001*	-13.23
3	941.1 ± 354.03	-400.9	-503.13 to -298.67	<0.001*	-30.76
4	946.6 ± 390.98	-395.4	-497.63 to -293.17	<0.001*	-31.57

Values are presented as mean ± standard deviation and mean change with a 95% confidence interval or n (%). P-values were calculated using the generalized estimating equation (GEE). Statistical significance was defined as P < 0.05.

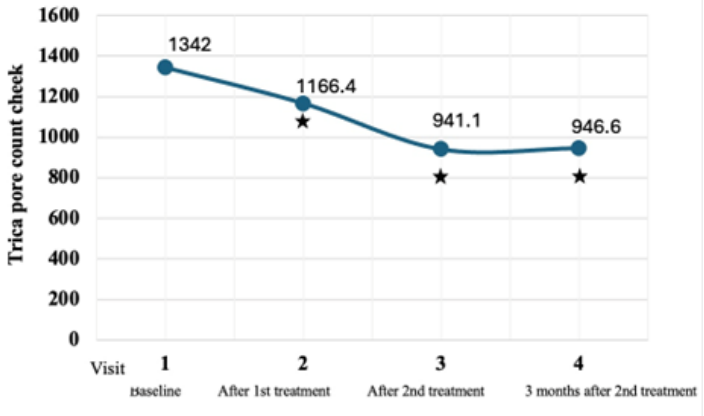

Figure 1 Changes in TRICA cheek pore count★, statistically significant change from baseline at each follow-up time

Mean baseline cheek sebum level was 147.25 ± 41.79. Sebum secretion decreased significantly following treatment, with reductions observed at each follow-up visit. Sebum levels decreased by 27.81% after the first treatment, further declining to 52% after the second treatment, and reaching 54.25% at the final follow-up, indicating a progressive and sustained reduction in sebum secretion over time.

Table 3 Changes in cheek sebum level from baseline at each follow-up time

Visit	Average Sebu Cheek	Beta coefficient	95%CI.	*p*-value	% Change
1	147.25 ± 41.79	Reference	-	-	-
2	102.95 ± 43.4	-44.3	-69.22 to -19.38	<0.001*	-27.81
3	65.75 ± 25.51	-81.5	-106.42 to -56.58	<0.001*	-52
4	68.2 ± 50.45	-79.05	-103.97 to -54.13	<0.001*	-54.25

Values are presented as mean ± standard deviation and mean change with a 95% confidence interval or n (%). P-values were calculated using the generalized estimating equation (GEE). Statistical significance was defined as p < 0.05.

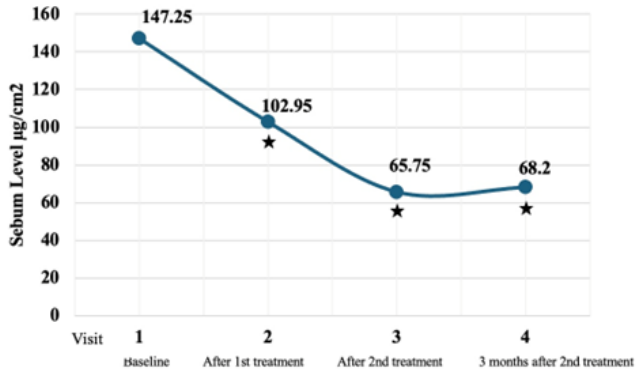

Figure 2 Cheek sebum levels ★, statistically significant change from baseline at each follow-up time

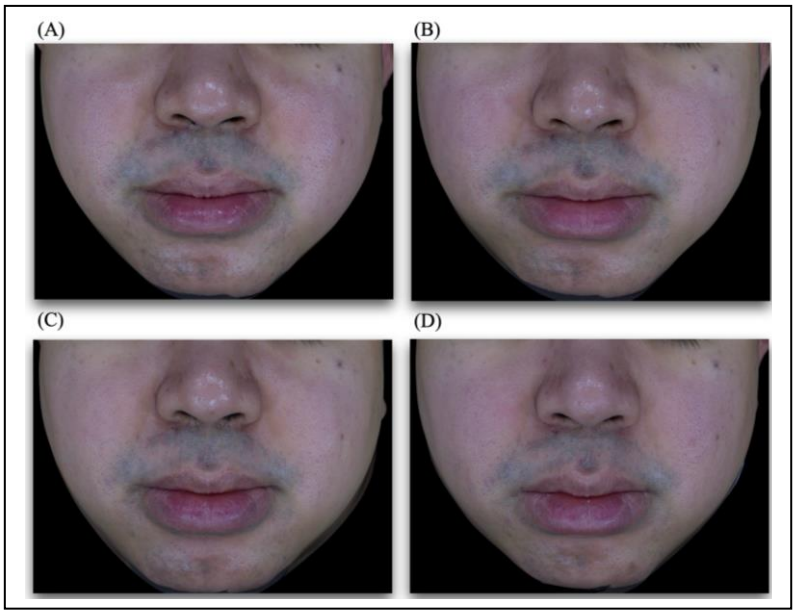

Figure 3 Photographs of a 36-year-old male with Fitzpatrick skin type III treated with continuous water-cooling monopolar radiofrequency. Images were obtained at (A) baseline, (B) 1 month after the first treatment, (C) 1 month after the second treatment, and (D) 3 months after the second treatment. Visible improvement in pore appearance, smoother skin texture, and reduced facial shine related to decreased sebum secretion are noted

No serious adverse events occurred during the study. All participants tolerated the procedure well. Mild transient erythema and discomfort were the most commonly reported effects and resolved without intervention.

4.2 Discussion

This study demonstrates that continuous water-cooling monopolar radiofrequency produces significant reductions in both facial pore count and sebum secretion, with improvements sustained during follow-up. The observed decrease in pore size suggests effective dermal remodeling, while the reduction in sebum output indicates a potential modulatory effect on sebaceous gland activity.

Use of the GEE model strengthened the analysis by accounting for intra-individual correlations across repeated measurements. Importantly, the favorable safety profile observed supports the suitability of this modality for patients seeking non-invasive treatment options with minimal downtime.

Dilated facial pores are increasingly recognized as a multifactorial aesthetic concern related to follicular morphology, sebaceous activity, and age-related structural changes in the skin (Sugiyama-Nakagiri et al., 2008; Uhoda et al., 2005). Higher sebum output has been shown to make facial pores appear larger and more noticeable (Jia & Feng, 2025). The parallel reduction in pore count and sebum levels observed in this cohort suggests that this modality may address multiple pathogenic contributors simultaneously. This dual effect is clinically relevant, as enlarged pores are unlikely to improve optimally when only one contributing factor, such as surface oiliness or dermal laxity alone, is targeted.

The observed clinical effects can be explained by the established biological responses to radiofrequency-induced dermal heating. Controlled thermal delivery stimulates collagen denaturation and subsequent neocollagenesis, leading to dermal tightening and improved support of the follicular unit (Jia & Feng, 2025). In addition, thermal modulation of sebaceous gland activity may account for the significant reduction in sebum secretion, as sebaceous gland size and activity are known to influence pore appearance (Kim et al., 2013). Continuous water cooling helps achieve sufficient heat in the deeper skin layers while protecting the skin surface, which improves treatment effectiveness and safety (Lee et al., 2024), thereby reducing sebum outflow to the skin surface. Both mechanisms are biologically plausible and may contribute simultaneously.

Traditional treatments for enlarged pores and oily skin, including topical products and chemical peels, often show variable results and may cause irritation or post-inflammatory pigmentary changes, particularly in darker skin types (Endly & Miller, 2017). Energy-based devices have gained interest as alternative approaches with more predictable tissue effects (Jia & Feng, 2025). Compared with ablative or fractional laser treatments, monopolar radiofrequency does not rely on chromophore absorption and is therefore less dependent on epidermal characteristics (Kim et al., 2014). This may help explain the good results seen in this study, which mainly included participants with Fitzpatrick skin types III and IV. In these skin types, avoiding excessive epidermal injury is especially important because of the higher risk of acute macular hyperpigmentation (AMH) associated with more aggressive resurfacing modalities.

Our findings are consistent with prior studies evaluating monopolar radiofrequency for aesthetic indications. Previous investigations have demonstrated improvements in skin laxity, patient-reported satisfaction, and histometric markers of dermal remodeling following monopolar radiofrequency treatment (Lee et al., 2024). Notably, Techapichetvanich et al. reported significant reductions in facial pores and sebum excretion in Thai patients treated with nonablative monopolar radiofrequency (Techapichetvanich et al., 2023). Although direct comparison of energy settings with previous monopolar RF studies is difficult due to differences in device design and cooling systems, the integrated water-cooling mechanism may enable more consistent dermal heating while minimizing excessive epidermal heat. In this study, energy levels were titrated according to a standardized protocol and adjusted based on participant tolerance to moderate discomfort to minimize the risk of complications.

Safety is a critical consideration when delivering thermal energy to the skin. The absence of serious adverse events in this study aligns with prior histological and clinical evidence supporting the safety of nonablative radiofrequency when appropriate parameters are used (Techapichetvanich et al., 2023). Continuous water cooling helps keep the epidermis at a safe temperature while allowing sufficient heat to reach the dermis layers (Lee et al., 2024). Patient tolerance was high, with only transient erythema and mild discomfort reported, consistent with previous subjective evaluations of monopolar radiofrequency treatments (Sanyal & Fabi, 2024).

Several limitations should be acknowledged. The small sample size (n = 10) and absence of a control group limit the generalizability of the findings and are insufficient to fully evaluate safety. Although statistically significant results were observed, the study should be considered preliminary and may not represent broader populations with diverse skin types or ethnic backgrounds. Follow-up was also limited to three months after the second treatment session. In addition, sebum measurements reflected surface levels

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and could not distinguish between reduced glandular production and altered sebum delivery to the skin surface. Future studies with larger cohorts (e.g., ≥50 participants), sex-specific analyses, longer follow-up, and histologic or imaging-based assessment of sebaceous gland changes are warranted. Nevertheless, continuous water-cooling monopolar radiofrequency appears to be a promising non-invasive option for improving enlarged facial pores and reducing sebum secretion with minimal downtime.

5. Conclusion

Continuous water-cooling monopolar radiofrequency is a safe and effective non-invasive treatment for enlarged facial pores and excessive sebum secretion. This modality appears particularly suitable for individuals with Fitzpatrick skin types III–IV, providing aesthetic improvement with minimal discomfort and downtime while maintaining a low risk of pigmentary complications.

6. Acknowledgements

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