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ORIGINAL RESEARCH

Comparison of the Efficacy and Safety of Pulsed Dye Laser, Intense Pulsed Light and Radiofrequency Therapy in the Treatment of Erythematotelangiectatic Rosacea

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Purpose: Optoelectronic advances have boosted interest in noninvasive rosacea treatments. Among them, pulsed dye laser (PDL), intense pulsed light (IPL), and radiofrequency (RF) therapy have been used to treat erythematotelangiectatic rosacea (ETR), and some therapeutic effects have been reported, but comparative studies are lacking. This study aimed to compare the efficacy and safety of PDL, IPL, and RF therapy for the treatment of ETR.

Patients and Methods: A retrospective evaluation was conducted of patients with ETR who completed phototherapy between June 2019 and June 2024. The treatment protocol included two sessions of 585 nm PDL therapy (6-week interval), three sessions of IPL (M22 590 filter) therapy (590–1200 nm, 4-week interval), or six sessions of multisource 3DEEP RF therapy (2-week interval), with a follow-up visit at 12 weeks post-final treatment. The clinical efficacy evaluation consisted of the Clinician Erythema Assessment (CEA) scale, patient self-assessment (PSA) scale, the overall efficacy rate, and the Rosacea-Specific Quality of Life instrument (RosaQoL). Safety was evaluated in terms of adverse reactions such as pain, purpura, erythematous edema, blistering, hyperpigmentation, and scarring.

Results: This study included 120 patients with ETR treated with PDL, M22 590, or RF therapy. Intragroup analysis revealed significant decreases in the CEA scale, PSA scale, and RosaQoL scores after treatment ($p<0.001$). The efficacy rates were 57.50%, 45.00%, and 67.50% for PDL, M22 590, and RF therapy, respectively, and no statistically significant intergroup differences were observed. Safety analysis confirmed that all the treatments were well tolerated.

Conclusion: PDL, IPL and RF therapy all produced short-term improvements in erythema and quality of life in patients with ETR. RF showed comparable efficacy with better tolerability, suggesting a comfortable, low downtime option, while PDL and IPL are vascular-targeted tools. These exploratory findings require confirmation in longer, dose-standardized prospective studies.

Keywords: erythematotelangiectatic rosacea, pulsed dye laser, intense pulsed light, radiofrequency, therapy

Introduction

Erythematotelangiectatic rosacea (ETR) is a chronic skin condition characterized by persistent facial redness, telangiectasia, and inflammation.[1] Its pathophysiological mechanisms include abnormal neurovascular regulation, innate immune activation, and excessive expression of proinflammatory factors such as vascular endothelial growth factor (VEGF).[2] These abnormalities lead to impaired microcirculation and increased vascular permeability, exacerbating skin redness and the inflammatory response. Skin barrier dysfunction and heightened sensitivity to environmental triggers further exacerbate patient symptoms.[3] These factors contribute to the chronicity and recalcitrance of the condition, necessitating effective therapeutic interventions.

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Traditional treatments for ETR include topical and systemic therapies, which often provide limited relief and are associated with various side effects. Topical agents (eg, metronidazole and ivermectin) and systemic antibiotics (eg, doxycycline) primarily target inflammation but show limited efficacy in managing the vascular components such as erythema and telangiectasias.[4] Long-term use of antibiotics has raised concerns regarding antibiotic resistance, whereas topical vasoconstrictors (eg, brimonidine) may cause rebound erythema.[3,5] Recent studies have found that low doses of oral isotretinoin (<0.5 mg/kg/day) are effective in improving symptoms and are well tolerated.[6] JAK1 inhibitors (such as upadacitinib) show potential in refractory cases.[7] Additionally, these therapies fail to address structural vascular abnormalities or cure the pathological basis, resulting in many patients being unsatisfied with the results.[1]

In recent years, advancements in laser and light-based technologies have revolutionized the management of ETR. Among these, pulsed dye laser (PDL), intense pulsed light (IPL), and radiofrequency (RF) therapy have emerged as promising modalities. Each of these technologies target the vascular components of rosacea through distinct mechanisms, offering varying degrees of efficacy and safety profiles. PDL therapy selectively targets hemoglobin via laser-light wavelengths of 585/595 nm, inducing vascular coagulation to treat erythema and telangiectasias with 68.9–82.5% efficacy,[8] and larger spot sizes (10 mm) can improve treatment efficiency.[9] Common transient purpura resolves spontaneously following PDL therapy, while scarring and hypopigmentation remain rare. IPL technology, such as with the M22 590 nm filter, employs broad-spectrum light to selectively target vascular lesions, with narrow-band IPL (500–600 nm) therapy demonstrating an excellent 35.6% lesion clearance after 3 sessions.[10] It effectively treats erythema and telangiectasias with fewer purpuric effects than pulsed dye laser therapy does, although its efficacy decreases in patients with Fitzpatrick skin types IV–VI because of melanin-mediated light absorption.[11] RF therapy induces controlled thermal remodeling of dermal collagen through collagen denaturation and neocollagenesis while simultaneously modulating vascular structures to reduce erythema. Clinical studies have demonstrated a 40–60% improvement in erythema after 3–6 FRF sessions, attributed to collagen reorganization and vessel coagulation effects.[12]

Most evidence for the efficacy of PDL and IPL therapies is derived from randomized trials and meta-analyses,[9,13,14] whereas RF therapy studies are small-scale or retrospective.[12,15] No head-to-head trials have directly compared RF with PDL/IPL therapy for ETR.[15] Despite the increasing use of these modalities, comparative studies on their efficacy, safety, and patient satisfaction in treating ETR remain limited. This study aimed to evaluate the current evidence on the efficacy of PDL, IPL, and RF therapy in managing ETR, focusing on their therapeutic mechanisms, clinical outcomes, and adverse effects. Furthermore, by synthesizing recent findings, this study seeks to provide clinicians with evidence-based insights to optimize treatment strategies for patients with ETR.

Materials and Methods

Subjects

Patients who were clinically diagnosed with ETR and treated with PDL, IPL, or RF therapy at the Department of Dermatology, First Affiliated Hospital of Army Military Medical University, from June 2019 to June 2024 were retrospectively evaluated. All patients who completed the prescribed treatment courses and follow-ups, did not use systematic medication, and received identical basic care (same-brand mild cleansers, moisturizers, and SPF30+ sunscreen) were included in this study. The exclusion criteria included the following: (1) comorbid skin conditions affecting study outcomes, such as eczema, psoriasis, or systemic lupus erythematosus (SLE); (2) severe underlying diseases interfering with treatment and recovery, such as diabetes mellitus with poorly controlled blood glucose, or severe hepatic/renal dysfunction; (3) contraindications or hypersensitivity to photoelectric therapy, such as photosensitive disorders, use of photosensitizing medications (eg, tetracycline-class drugs), or keloid predisposition; and (4) prior use of medications (eg, oral isotretinoin, antibiotics) or photoelectric therapies targeting erythematous telangiectasia within 3 months before treatment initiation, including topical corticosteroids.

Treatment Protocol

A total of 120 patients received one of three treatments (PDL, M22 590, or RF) with the following treatment protocols: (1) 585 nm PDL therapy in 2 sessions at 6-week intervals; (2) M22 590 therapy in 3 sessions at 4-week intervals; (3) RF

therapy in 6 sessions at 2-week intervals. Patients were followed up at 12 weeks after the final treatment. After the treatment, the local area was kept clean, moisturized, and protected from the sun. Makeup was avoided.

During the treatment, the settings and evaluations of the treatment parameters were jointly completed by two dermatologists with more than 5 years of experience in the treatment of rosacea. The specific process was to preliminarily formulate the treatment parameters according to the skin type and the severity of the skin lesions, and then confirm them through discussion by the two dermatologists before implementation. Any adjustments of the parameters were recorded throughout the treatment. The parameter settings were as follows: (1) PDL (Vbeam, Candela, 585 nm): pulse width 6 ms/10 ms, energy density 7–10.5 J/cm^2, and spot size 7 mm. (2) M22 590 (M22, Lumenis, 590–1200 nm): double pulse, pulse width 6–10 ms, pulse delay 30–40 ms, energy density 15–20 J/cm^2, and spot size 15×35 mm. (3) RF (3DEEP, EndyMed, Multisource): On the basis of the severity of erythematous inflammation, thermal tolerance, and skin response during treatment, the following treatment parameters were selected for noninvasive mode. For cheek areas, a small TC handpiece with a treatment energy ranging from 8–20 W, was used, and a total of 24–30 passes were employed. For the forehead, mandible, and nasal regions, the Ifine small-area TC handpiece was employed with a treatment energy of 2–3 W, delivering 10–15 passes. Each pass duration was set at 30s. The energy level was adjusted to maintain a mildly warm sensation tolerable to the patient. For patients demonstrating better thermal tolerance, the energy was appropriately increased, whereas for those with lower tolerance, the energy was reduced accordingly. Energy adjustments were made at 1–2 W intervals per modification.

Evaluations

Digital photographs were obtained at baseline and at the last follow-up visit using a Canon EOS 70D (Canon, Tokyo, Japan). Efficacy was evaluated by comparing standardized digital photographs taken before and after treatment. The indicators included the clinical symptom score, total effective rate, and RosaQoL score. Photographic assessment of treatment efficacy based on improvements in the presentation of erythema and telangiectasia was performed by 2 dermatologist using the Clinician Erythema Assessment (CEA) scale (0=clear, 1=almost clear, 2=mild, 3=moderate, 4=severe) (Table 1). The patient's self-assessment (PSA) scale score (Table 2) and the Rosacea-Specific Quality-of-Life instrument (RosaQoL) score (Table 3) were self-assessed by the patients. The RosaQoL consisted of 19 questions, and a higher score indicated a worse quality of life.

The efficacy index of each patient was calculated using the following formula: efficacy index = (score before treatment - score after treatment)/score before treatment × 100%. On the basis of the efficacy index, the curative effect was classified into four grades: improvement [excellent] (efficacy index ≥75%), improvement [good] (efficacy index

Table 1 Clinician Erythema Assessment (CEA) Scale

	CEA
0 = Clear	Clear skin with no signs of erythema
1 = Almost clear	Almost clear; slight redness
2 = Mild	Mild erythema; definite redness
3 = Moderate	Moderate erythema; marked redness
4 = Severe	Severe erythema; fiery redness

Table 2 Patient Self-Assessment (PSA) Scale

	PSA
0 = Clear	Clear of unwanted redness
1 = Almost clear	Nearly clear of unwanted redness
2 = Mild	Somewhat more redness than I prefer
3 = Moderate	More redness than I prefer
4 = Severe	Completely unacceptable redness

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Table 3 Adjusted Chinese Version of the Rosacea-Specific Quality-of-Life (RosaQoL) Instrument

RosaQoL Items	Hypothesized Construct
1. I worry that my rosacea may be serious	Emotion
2. My rosacea burns or stings	Symptoms
3. I worry about getting scars from my rosacea	Emotion
4. I worry that my rosacea may get worse	Emotion
5. I worry about side effects from rosacea medications	Emotion
6. My rosacea is irritating	Symptoms
7. I am embarrassed by my rosacea	Emotion
8. I am frustrated by my rosacea	Emotion
9. My rosacea makes my skin sensitive	Symptoms
10. I am annoyed by my rosacea	Emotion
11. I am bothered by the appearance of my skin (redness, blotchiness)	Emotion
12. My rosacea makes me feel self-conscious	Emotion
13. I am bothered by persistence/reoccurrence of my rosacea	Emotion
14. I avoid certain foods or drinks because of my rosacea	Functioning
15. My skin feels bumpy (uneven, not smooth, irregular)	Symptoms
16. My skin feels flushed	Symptoms
17. My skin gets irritated easily (cosmetics, aftershaves, cleansers)	Symptoms
18. I think about my rosacea	Emotion
19. I avoid certain environments (heat, humidity, cold) because of my rosacea	Functioning

50–74%), improvement [fair] (efficacy index 25–49%), and improvement [poor] (efficacy index <25%). The total effective rate was calculated as (good cases+excellent cases)/total number of cases × 100%.

Adverse reactions such as pain, purpura, erythema, edema, blisters, and pigmentation were recorded throughout the study period. The pain score was evaluated immediately after each treatment with a visual analog scale (VAS) ranging from 0 to 10, where 0 indicated no pain, and 10 indicated the greatest pain imaginable.

Statistical Evaluation

All the data analyses were performed using SPSS software (version 25.0; SPSS, Inc., Chicago, IL). Statistical significance was set at $P<0.05$. The data are expressed as the mean ± standard deviation or as percentages. A paired samples *t*-test was used for intragroup comparisons before and after treatment. Analysis of variance or a chi-square test was used for comparisons between groups before and after treatment.

Results

All 120 individuals completed all the treatments and were included in the final statistical analysis. The clinicodemographic information of the participants is presented in Table 4, which indicates that no significant difference was observed among the three groups in terms of age, gender, disease duration, or the distribution of Fitzpatrick skin types ($P>0.05$), ensuring comparability.

After treatment, the clinical symptom (CEA and PSA) scale scores and the RosaQoL scores of the patients in the three groups significantly decreased compared with those at baseline, as illustrated in Figures 1–3. A comparison of patients in the different treatment groups before and after treatment is shown in Figure 4.

The total effective rates of the PDL group, M22 590 group, and RF group were 57.50%, 45.00%, and 67.50%, respectively, with no significant intergroup difference ($P>0.05$), as shown in Table 5. Furthermore, the CEA scale scores decreased after all three treatments by 1.27 ± 0.82, 0.95 ± 0.78, and 1.48 ± 0.75 points, respectively, and the intergroup differences were significant ($P<0.05$), as presented in Table 6. The PSA scale scores decreased after all three treatments by 1.32 ± 1.23, 1.07 ± 1.00, and 1.68 ± 0.86 points, respectively, and the intergroup differences were significant ($P<0.05$),

Table 4 Statistical Analysis of the Basic Conditions of the Patients

Index	Group			χ2/H/F value	P
	PDL (n=40)	M22 590 (n=40)	RF (n=40)		
Age	34.70 ± 10.09	31.50 ± 4.73	35.90 ± 9.52	2.890	0.060
Sex				0.517	0.772
Male	2 (5.00)	1 (2.50)	1 (2.50)		
Female	38 (95.00)	39 (97.50)	39 (97.50)		
Lesion duration (year)	3.60 ± 3.68	3.55 ± 3.38	4.26 ± 3.49	0.506	0.604
Fitzpatrick skin type				2.542	0.637
II	2(5.00)	1(2.50)	3(7.50)		
III	12(30.00)	17(42.50)	16(40.00)		
IV	26(65.00)	22(55.00)	21(52.50)		

Abbreviations: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; RF, Radiofrequency.

as presented in Table 7. The RosaQoL scores decreased after all three treatments by 8.82 ± 2.80, 7.53 ± 2.29, and 10.82 ± 3.63, respectively, with significant intergroup differences between groups (P<0.001), as shown in Table 8.

In terms of safety, the average treatment-related pain scores of the patients were 5.03±0.83 for the PDL, 1.02±0.89 for the M22 590, and 0.38±0.54 for the RF groups (P<0.001). Other adverse reactions, including erythematous edema, facial desquamation and dryness, purpura, blisters, hyperpigmentation, and scars, were reported. The incidences of adverse reactions in the PDL group, M22 590 group, and RF group were 100%, 27.5%, and 5%, respectively, and the differences among the groups was significant (P<0.001), as presented in Table 9. Overall, the three treatment modalities demonstrated desirable overall safety profiles, although PDL therapy resulted in higher incidences of purpura and erythema/edema (which self-resolved within 1–2 weeks), whereas RF therapy exhibited no significant adverse effects.

Discussion

This study presents the first systematic comparison of the clinical efficacy and safety of three energy-based devices – a 585 nm PDL, an M22 590 filter, and an RF device - in the treatment of ETR. At the 12-week post-treatment visit, the results revealed significant decreases in the CEA, PSA, and RosaQoL scores across all three modalities (p<0.001), underscoring their capacity to address both the objective and subjective dimensions of ETR. The effective rates of the three treatments were 57.50%, 45.00%, and 67.50%, respectively. No statistically significant differences were observed

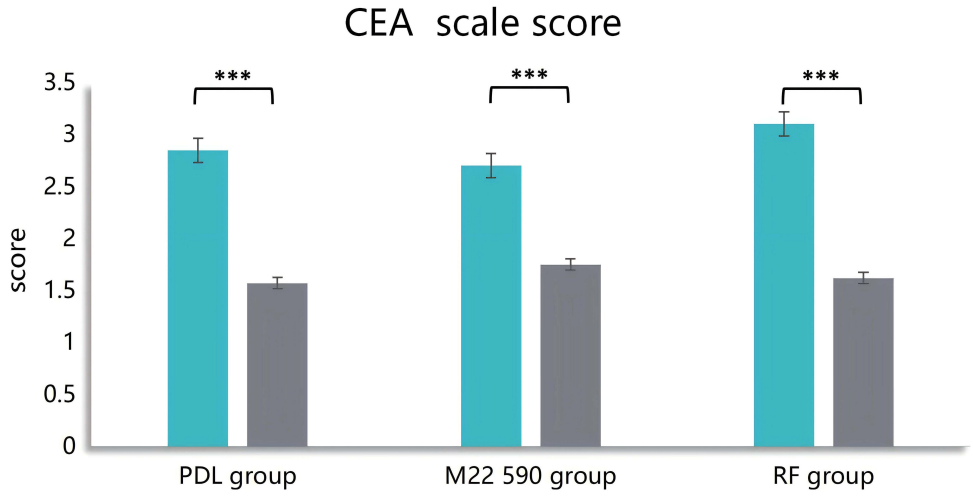

Figure 1 The average CEA scale score before and after PDL treatment. Before treatment: 2.85 ± 0.83; after treatment: 1.57 ± 0.87 (P<0.001; ***indicates a statistically significant difference). The average CEA scale score before and after M22 590 treatment. Before treatment: 2.70 ± 0.69; after treatment: 1.75 ± 0.93 (P<0.001; ***indicates a statistically significant difference). The average CEA scale score before and after RF treatment. Before treatment: 3.10 ± 0.78; after treatment: 1.62 ± 0.93 (P<0.001; ***indicates a statistically significant difference).

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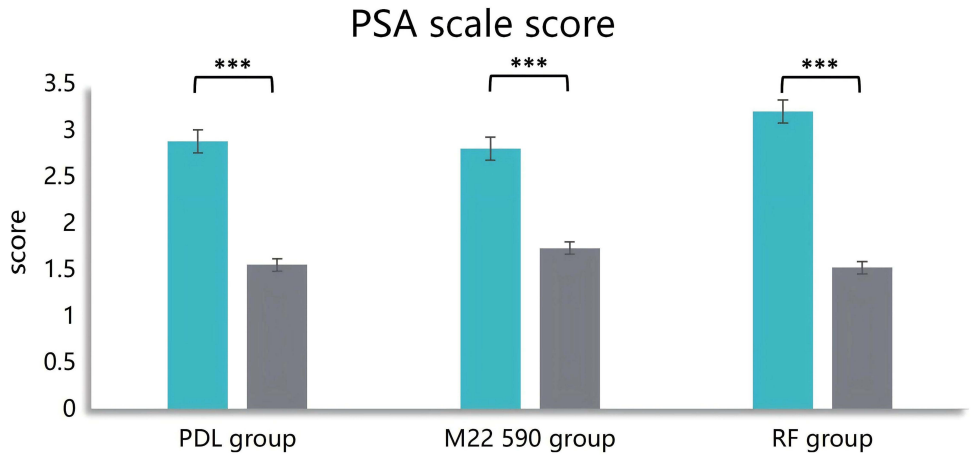

Figure 2 The average PSA scale score before and after PDL treatment. Before treatment: 2.88±0.97; after treatment: 1.55 ± 0.85 (P<0.001; ***indicates a statistically significant difference). The average PSA scale score before and after M22 590 treatment. Before treatment: 2.80±1.04; after treatment: 1.73 ± 0.99 (P<0.001; ***indicates a statistically significant difference). The average PSA scale score before and after RF treatment. Before treatment: 3.20±0.69; after treatment: 1.52 ± 1.01 (P<0.001; ***indicates a statistically significant difference).

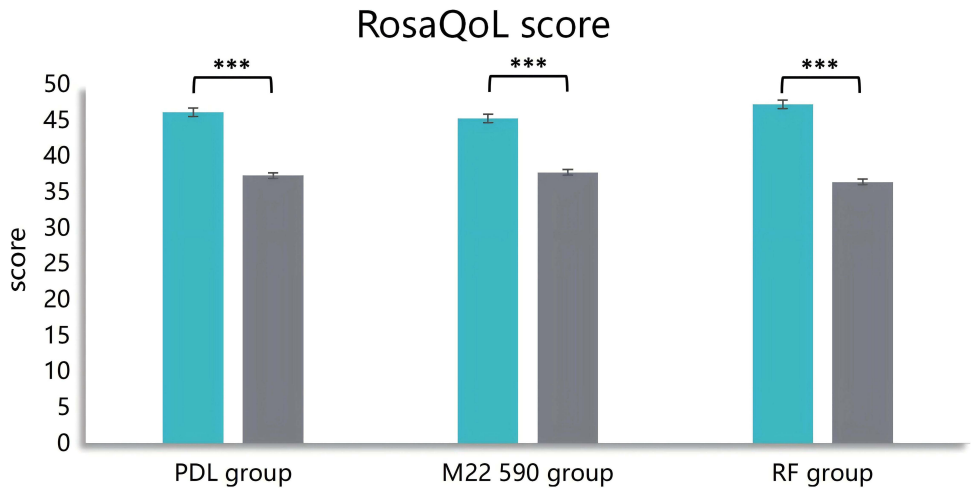

Figure 3 The average RosaQoL score before and after PDL treatment. Before treatment: 46.13±4.54; after treatment: 37.30 ± 4.70 (P<0.001; ***indicates a statistically significant difference). The average RosaQoL score before and after M22 590 treatment. Before treatment: 45.25±3.70; after treatment: 37.73 ± 4.53 (P<0.001; ***indicates a statistically significant difference). The average RosaQoL score before and after RF treatment. Before treatment: 47.23±5.67; after treatment: 36.40 ± 6.03 (P<0.001; *** indicates a statistically significant difference).

among the three groups, indicating comparable efficacy in improving erythema, telangiectasia, and quality of life for ETR patients. These findings align with those of previous research by Ruan et al, who reported 68.9–77.5% efficacy rates for PDL and IPL therapy in reducing the size of erythema areas.[16] Notably, Li et al first reported a significant reduction in the area of erythema following RF treatment, validating the therapeutic potential of radiofrequency technology in vascular dermatoses.[12]

The comparable efficacy of RF to that of PDL and IPL is intriguing, as RF does not directly target hemoglobin. Its effectiveness may stem from indirect anti-inflammatory effects, enhanced lymphatic drainage, and collagen remodeling, which collectively reduce erythema and improve skin texture. There is no light or heat selectivity restriction, which is especially suitable for deep vascular lesions or photosensitive skin patients. This finding aligns with recent studies highlighting the role of radiofrequency in modulating neurovascular hyperactivity and immune responses in rosacea.[12] The efficacy of RF stems from synergistic suppression of neuroimmune axes (eg, TRPV1/CGRP and PACAP), down-regulation of key cytokines (IL-17 and IFN-γ), and restoration of dermal matrix integrity.[17,18] Conversely, PDL and IPL therapy directly address vascular abnormalities, with polychromatic IPL (500–1200 nm) offering versatility in treating

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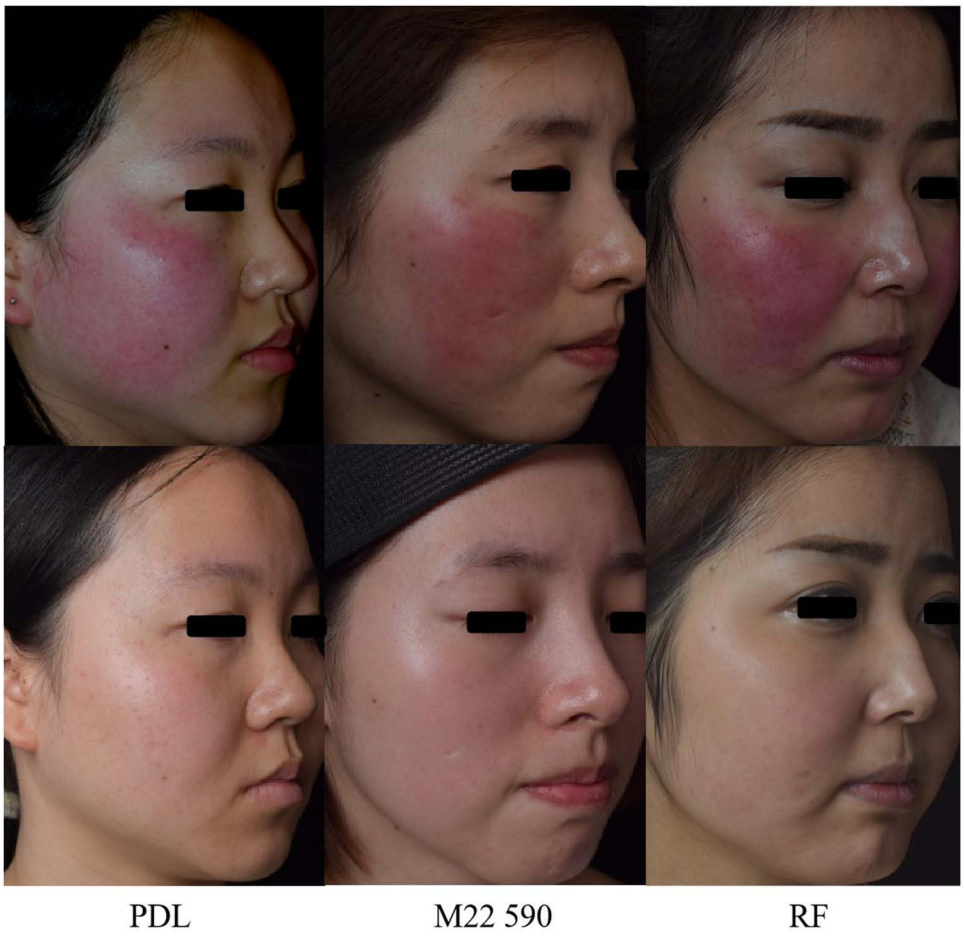

Figure 4 Comparison of patients in different treatment groups before and after treatment.

heterogeneous lesions. There was no significant difference in the effectiveness of different treatments, indicating that different pathways, such as vascular destruction, photobioregulation and skin remodeling, can achieve similar short-term clinical endpoints in patients with ETR.[2,13,16]

Safety profiles differed notably among the modalities. The 585 nm PDL group exhibited higher rates of transient purpura and erythema/swelling, which is consistent with the mechanism by which it induces microvascular coagulation.[19] These side effects, although self-limiting, may impact patient satisfaction and adherence, particularly in individuals with darker skin tones or low pain tolerance.[20] In contrast, RF demonstrated an exceptional safety profile, with no reported adverse events, likely attributable to its nonablative, nonchromophore-dependent energy delivery.[12,21] IPL showed an intermediate pattern, with fewer purpuric events than PDL, and it carries a risk of mild erythema and edema; in addition,

Table 5 Comparison of the Total Effective Rates After the Three Types of Treatments

Group	Efficacy Division (n, %)				Total Effective Rate (n, %)
	Poor	Fair	Good	Excellent	
PDL	5(12.50)	12(30.00)	19(47.50)	4(10.00)	23(57.50)
M22 590	9(22.50)	13(32.50)	16(40.00)	2(5.00)	18(45.00)
RF	3(7.50)	10(25.00)	22(55.00)	5(12.50)	27(67.50)
$\chi 2$ value					4.140
P					0.126

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Table 6 Comparison of CEA Scale Scores Before and After Surgery Among the Three Groups

CEA scale score	PDL group	M22 590 group	RF group	F value	*P*
Before treatment	2.85 ± 0.83	2.70 ± 0.69	3.10 ± 0.78	2.766	0.067
After treatment	1.57 ± 0.87	1.75 ± 0.93	1.62 ± 0.93	0.393	0.676
(Before treatment - after treatment)	1.27 ± 0.82	0.95 ± 0.78	1.48 ± 0.75	4.573	0.012

Notes: Before treatment - after treatment indicates the difference between the CEA score before treatment and the CEA score after treatment. An analysis of variance revealed a statistically significant difference (P<0.05) between groups.

Table 7 Comparison of PSA Scores Before and After Surgery Among the Three Groups

PSA Scale Score	PDL group	M22 590 group	RF group	F value	*P*
Before treatment	2.88 ± 0.97	2.80 ± 1.04	3.20 ± 0.69	2.177	0.118
After treatment	1.55 ± 0.85	1.73 ± 0.99	1.52 ± 1.01	0.525	0.593
(Before treatment - after treatment)	1.32 ± 1.23	1.07 ± 1.00	1.68 ± 0.86	3.365	0.038

Notes: Before treatment - after treatment indicates the difference between the PSA score before treatment and the PSA score after treatment. An analysis of variance revealed a statistically significant difference (P<0.05) between groups.

Table 8 Comparison of RosaQoL Score Before and After Treatment Among the Three Groups

RosaQoL Score	PDL Group	M22 590 Group	RF Group	F value	*P*
Before treatment	46.13 ± 4.54	45.25 ± 3.70	47.23 ± 5.67	1.769	0.175
After treatment	37.30 ± 4.70	37.73 ± 4.53	36.40 ± 6.03	0.695	0.501
(Before treatment - after treatment)	8.82 ± 2.80	7.53 ± 2.29	10.82 ± 3.63	12.635	<0.001

Notes: Before treatment - after treatment indicates the difference between the RosaQoL score before treatment and the RosaQoL score after treatment. An analysis of variance revealed a statistically significant difference (P<0.001) between groups.

Table 9 Comparison of Adverse Reactions Among the Three Groups

Adverse Reactions	Group (n, %)			$\chi 2$	*P*
	PDL (n=40)	M22 590 (n=40)	RF (n=40)		
Erythema edema	8(5.00)	7(17.50)	2(5.00)		
Facial desquamation and dryness	0(0)	6(15.00)	0(0)		
Purpura	40(100.00)	0(0)	0(0)		
Blisters	3(7.50)	0(0)	0(0)		
Hyperpigmentation	2(5.00)	0(0)	0(0)		
Scars	0(0)	0(0)	0(0)		
None	0(0)	29(67.50)	38(95.00)		
Incidence	40(100.00)	11(27.50)	2(5.00)	79.955	<0.001

caution is needed when treating patients with dark skin (Fitzpatrick IV–VI) because of the potential risk of pigment abnormalities due to increased melanin absorption, albeit at low frequencies because of its broad wavelength spectrum and adjustable parameters. These findings reinforce the importance of tailoring treatments to minimize adverse effects while maintaining efficacy, especially in populations with heightened susceptibility to postinflammatory sequelae.[20,22] Additionally, the role of treatment parameters (eg, fluence, pulse duration, and spot size) in optimizing efficacy and safety warrants further investigation.[19] For instance, narrower IPL bandwidths (eg, 500–600 nm) have shown enhanced efficacy in treating ETR with fewer sessions, whereas larger PDL spot sizes (10 mm) may reduce purpura risk.[14]

Overall, RF therapy demonstrated more significant numerical reductions in the CEA, PSA, and RosaQoL scores. Combined with the lowest pain scores and incidence of adverse events, these data indicate that radiofrequency therapy effectively controls erythema symptoms with excellent tolerability. The results advocate for expanding the therapeutic arsenal for ETR beyond conventional laser and light-based devices. RF emerges as a particularly compelling option for patients prioritizing comfort, seeking minimal downtime and the avoidance of purpura, such as those with Fitzpatrick skin types IV–VI or with occupational constraints.[20] However, PDL and IPL therapy remain the first-line choices for targeted vascular ablation, especially in patients with persistent telangiectasia.[23] The high patient satisfaction with RF (67.50% efficacy) also underscores the potential of combining modalities, for example, using RF for diffuse erythema and IPL/PDL for residual vessels, to optimize outcomes.[24] Finally, exploring sequential or combination therapies involving energy-based devices with topical brimonidine or oral doxycycline/isotretinoin may represent a breakthrough in optimizing ETR management.[25,26] Future studies should also explore molecular biomarkers (eg, CXCL9 and VEGF) for predicting treatment response and refining patient selection.[27,28]

This study employed a multidimensional evaluation system incorporating CEA scale, PSA scale, and RosaQoL scores, overcoming the limitations of traditional single-parameter assessments (eg, erythema area). The significant positive correlation between the CEA scale score and the absolute erythema area aligns with the findings of the study by Pan et al of high consistency between the CEA scale and IGA scores, confirming its reliability as an objective efficacy indicator.[29] Improvements in the PSA scale score reflected patient satisfaction with symptom control, whereas reduced RosaQoL scores indicated therapeutic alleviation of social anxiety and emotional distress. Future research should integrate VISIA red-area analysis with skin biomechanical measurements (eg, TEWL and epidermal hydration) to comprehensively evaluate the long-term effects of energy-based devices on skin barrier function and microcirculation.[30,31]

This study is limited by its single-center design, modest sample size, and short-term follow-up. First, although each cohort had a uniform 12-week post-treatment assessment, the number and cadence of sessions differed by modality according to routine clinical protocols, and cross-modality dose normalization (eg, total delivered energy/exposure time) was not feasible retrospectively; therefore, the between-group comparisons should be interpreted with caution. Second, although RF showed numerically larger reductions in CEA/PSA/RosaQoL, the groups did not differ significantly in total effective rate, and the RF group had a slightly higher baseline CEA; thus, residual confounding (eg, baseline severity, vessel morphology, and parameter titration) may influence the comparative effect sizes. The outcome assessors were not fully blinded to modality due to the characteristic post-PDL purpura; although predefined scales and patient-reported measures were used, observer bias cannot be completely excluded. Third, follow-up beyond 12 weeks after the final session was not available and therefore it is difficult to assess whether such favorable short-term control and safety features translate into more stable long-term disease control or reduced rates of recurrence. Prospective, dose-standardized and blinded multicenter studies with ≥6–12-month follow-up are warranted to validate long-term effectiveness and safety across modalities.

Conclusion

In summary, 585 nm PDL, M22 590, and RF therapies are all effective and safe for the treatment of ETR and present distinct risk-benefit profiles. The absence of intergroup efficacy differences highlights the importance of implementing individualized treatment plans, while the superior safety and painless nature of RF therapy makes it a promising alternative for risk-averse patients. These findings contribute to the evolving paradigm of ETR management, emphasizing multimodal strategies to address both vascular and inflammatory components of the disease. Future multicenter RCTs are warranted to validate the long-term efficacy and synergistic effects of combination therapy.

Abbreviations

PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; RF, Radiofrequency; ETR, Erythematotelangiectatic Rosacea; CEA, Clinician Erythema Assessment; PSA, Patient Self-Assessment; RosaQoL, Rosacea-Specific Quality of Life (instrument); VAS, Visual Analog Scale; VEGF, Vascular Endothelial Growth Factor; SLE, Systemic Lupus Erythematosus; IL-17, Interleukin-17; IFN-γ, Interferon-gamma.

Ethics Approval

This study was approved by the Ethics Committee of the First Affiliated Hospital of Army Medical University, PLA (NO. KY2024207). Written consent was obtained from all patients before treatment. This study adheres to the ethical standards of the Declaration of Helsinki and has been approved by the relevant ethics committees. Clinical photographs from three patients are included in this article. Written informed consent for publication of their clinical details and accompanying images was obtained from all three individuals. No other identifying personal data are presented.

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 report no conflicts of interest in this work.

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