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Original Article

Comparison of the efficacy and safety of pulsed dye laser, narrow-band intense pulsed light, and broad-band intense pulsed light in the treatment of erythematotelangiectatic rosacea

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Abstract: Background: Erythematotelangiectatic rosacea (ETR) is a chronic dermatological condition characterized by persistent facial erythema and visible telangiectasia. This study aims to compare the efficacy, safety, and patient satisfaction associated with pulsed dye laser (PDL), narrow-band intense pulsed light (NB-IPL), and broad-band IPL (BB-IPL) in the treatment of ETR. Methods: A total of 112 patients diagnosed with ETR between May 2021 and April 2024 were retrospectively analyzed. Patients were divided into three treatment groups: PDL (n = 36), NB-IPL (n = 38), and BB-IPL (n = 38). Treatment outcomes were assessed via VISIA imaging, the Clinical Erythema Assessment (CEA), the Rosacea Quality of Life scale (RosaQoL), and recurrence rates. Pain intensity was measured using the Visual Analogue Scale (VAS), and skin parameters were analyzed pre- and post-treatment. Correlation analyses were performed to assess associations between treatment modalities, efficacy, and safety profiles. Results: NB-IPL significantly reduced erythema and porphyrin levels compared to PDL and BB-IPL ($P < 0.05$). BB-IPL showed the most pronounced reduction in sebum levels but was associated with a higher incidence of pigmentation changes. PDL demonstrated comparable efficacy to NB-IPL in reducing erythema while presenting fewer adverse effects. Recurrence rates were low and showed no significant differences among the three groups. Both PDL and NB-IPL demonstrated negative correlations with CEA scores and energy density, whereas NB-IPL showed stronger positive correlations with treatment outcomes and negative associations with sebum levels when compared to BB-IPL. While IPL improves emotional and symptomatic domains in RosaQoL, no significant differences in functional domains were observed. Conclusion: NB-IPL demonstrated superior efficacy in erythema reduction, while BB-IPL effectively reduced sebum production but carried a higher risk of pigmentation. PDL provided a balanced therapeutic profile, combining satisfactory efficacy with fewer adverse events.

Keywords: Erythematotelangiectatic rosacea, pulsed dye laser, narrow-band intense pulsed light, broad-band IPL, efficacy

Introduction

Rosacea is a chronic inflammatory dermatological condition characterized by facial erythema, telangiectasia, and, in some cases, inflammatory papules and pustules. It affects approximately 1% to 22% of the population across various regions [1]. Erythematotelangiectatic rosacea (ETR) is a subtype that predominantly manifests as persistent facial redness and prominent visible blood vessels, which not only present aesthetic concerns but also impose a significant psychological burden on affected individuals [2]. Although common, the pathophysiology of rosacea remains incompletely understood. Current evidence suggests a multifactorial etiology involving genetic predisposition, environmental triggers, neurovascular dysregulation, and chronic inflammation [3].

Treatment strategies for ETR are diverse, ranging from topical agents to oral medications, and device-based interventions. Among these, laser and light-based therapies have gained prominence due to their ability to directly target the vascular components of the disease, providing both symptomatic relief and cosmetic improvement [4-6]. Pulsed dye laser (PDL) and intense

pulsed light (IPL) technologies are particularly notable, as they enable selective photothermolysis of cutaneous chromophores - especially oxyhemoglobin - within superficial blood vessels, thereby diminishing erythema and telangiectasia [7-9].

PDL, a well-established modality in rosacea management, operates within a wavelength range that is preferentially absorbed by hemoglobin, promoting selective photothermolysis of superficial cutaneous vasculature with minimal collateral tissue damage [8, 10]. Similarly, IPL delivers non-coherent, broad-spectrum light capable of addressing various dermatological concerns, including vascular lesions. The clinical versatility of IPL is largely attributed to its adjustable parameters, which allow individualized treatment based on patient-specific characteristics and the severity of rosacea. However, its broad wavelength range may lead to non-selective photothermal effects, potentially increasing the risk of adverse events such as post-inflammatory hyperpigmentation. Technological advancements have led to the development of narrow-band IPL, which focuses energy delivery within a more specific wavelength spectrum to enhance target specificity and minimize adverse effects [9, 11].

Despite the clinical promise of these technologies, comparative data on the efficacy and safety of different laser and IPL modalities for treating ETR remain limited. While previous studies have assessed individual modalities, direct head-to-head comparisons are scarce, hindering evidence-based treatment selection tailored to patient-specific needs and therapeutic goals [12, 13]. Moreover, evaluating clinical efficacy is crucial, as treatment adherence and patient satisfaction are strongly influenced by both visible improvements and procedural tolerability [14].

This study aims to address these gaps by retrospectively comparing the therapeutic outcomes of PDL, narrow-band IPL (NB-IPL), and broad-band IPL (BB-IPL) in patients with ETR, utilizing a large patient cohort and comprehensive, objective evaluation metrics.

Methods

Subject selection and ethical approval

This retrospective study included 112 patients diagnosed with ETR who received treatment at Shuguang Hospital, affiliated with Shanghai University of Traditional Chinese Medicine, from May 2021 to April 2024. Patient data were sourced from the hospital's medical record system. The study protocol was approved by the Institutional Review Board and Ethics Committee of Shuguang Hospital affiliated with Shanghai University of TCM. Due to its retrospective design and the use of anonymized patient data, the requirement for informed consent was waived. This exemption was granted in accordance with ethical regulations and regulatory guidelines relevant for retrospective research, as the study posed no additional risk to patient welfare or clinical care.

Inclusion and exclusion criteria

Eligible participants were adults aged 18 years or older with Fitzpatrick skin types II to IV. All patients met the diagnostic criteria for ETR as outlined in previous literature [15], had completed the full course of treatment and follow-up assessments, and had complete and reliable clinical data.

Exclusion criteria included pregnancy or lactation, use of oral or topical medications within one month prior to treatment, or receipt of other photoelectric treatments within the same timeframe. Patients with immune-related or connective tissue disorders, photosensitivity, severe systemic organ dysfunction, mental disorders, a history of scarring or sensitivity to electric stimulation, or concurrent skin infections or trauma in the treatment area were also excluded.

Diagnostic criteria for ETR

The diagnosis of ETR was established based on the presence of the following clinical features: (1) Persistent Erythema: Chronic facial redness predominantly affecting the cheeks, nose, chin, or forehead. (2) Telangiectasia: Visible dilated capillaries on the facial skin surface. (3) Flushing: Frequent episodes of flushing or blushing, often prolonged in duration. (4) Subjective symptoms: Accompanying sensations of burning or stinging, commonly associated with erythema and telangiectasia. (5) Exclusion of Other Conditions: Differential diagnoses such as acne, seborrheic dermatitis, and contact dermatitis were carefully ruled out.

Grouping standards and treatment methods

Participants were categorized into three distinct groups based on the intervention received: the PDL group (n = 36), the NB-IPL group (n = 38), and the BB-IPL group (n = 38).

Before treatment, patients were instructed to cleanse their faces. A comprehensive skin evaluation was then performed utilizing VISIA imaging, dermoscopy, and the Clinical Erythema Assessment (CEA) to assess erythema severity. For superficial anesthesia, either the left or right cheek - randomly selected - was anesthetized with compound lidocaine cream (Approval No.: H20063466, Tongfang Pharmaceutical Group Co., Ltd., China) for 40-50 minutes. Prior to anesthesia, the treatment area was thoroughly cleansed and disinfected. Protective goggles were provided to all patients throughout the procedure.

After each treatment session, a thin layer of 0.1% triamcinolone ointment (Approval No.: H13022077, Tangshan Hongxing Pharmaceutical Co., Ltd., China) was applied evenly over the entire face. Patients were instructed to apply a broad-spectrum sunscreen with SPF 30 daily and to follow standard photoprotection measures. Final evaluations were conducted four weeks after the completion of the third treatment session. Any adverse events occurring during the treatment period were documented.

Visual analogue scale (VAS): The VAS was employed to evaluate pain intensity on the first and seventh days following treatment across all groups. Pain levels were categorized as follows: no pain (0 point), mild pain (1-3 points), moderate pain (4-6 points), severe pain (7-9 points), and extreme pain (10 points). The VAS is a widely validated and reliable tool for subjective pain assessment, with a reported Cronbach's alpha coefficient of 0.94 [16].

Energy density: Patients in the PDL group were treated using a pulsed dye laser system (Harmony XL, Alma Lasers Ltd., Caesarea, Israel) with a wavelength range of 500-600 nm, a pulse duration of 10-15 milliseconds, and a fluence of 8.4-10.6 J/cm^2. The laser was delivered using a 1 cm by 3 cm spot size, with an overlap of 15-20% to ensure adequate coverage. A cold water spray was applied during the procedure to reduce discomfort, followed by ice pack application post-treatment. Clinical endpoints were defined as the immediate darkening or fading of erythema and the blurring, blanching, or disappearance of telangiectatic vessels. Each patient received three treatment sessions, spaced four weeks apart.

For the IPL groups, treatment was performed using an IPL device (B680, AnchorFree, China). Parameters were individualized based on the patient's skin type, the severity of rosacea, and observed treatment response. Initially, a test light pulse was applied to the submandibular area (below the jawline). The treatment handpiece, pre-coated with a cooling gel, was positioned perpendicular to the skin surface before light emission. Appropriate parameters were determined based on clinical responses, including erythema darkening, mild purpura, indistinct vascular outlines, or mild sensations of burning or pain.

In the BB-IPL group, the settings included a wavelength range of 590-1200 nm, a spot size of 35 mm × 15 mm, dual pulses with pulse durations of 3-4.5 ms, pulse delays of 20-40 ms, and energy densities ranging from 14.00 to 19.00 J/cm^2. In contrast, the NB-IPL group was treated with a wavelength range of 500-600 nm, a spot size of 30 mm × 10 mm, pulse durations of 10 or 12 ms, and energy densities of 8.40-11.60 J/cm^2. For both IPL groups, the overlap of treatment areas was controlled to remain below 10% to minimize the risk of overexposure.

VISIA system

Clinical photographs and red area images of rosacea lesions were captured using the VISIA system (version 6.0, Canfield Scientific Inc., USA) both before treatment and one month after the final treatment session. Three independent dermatologists, blinded to the treatment allocation, evaluated these images to assess changes in erythema and telangiectasia. The VISIA system provided absolute scores for various skin features, including spots, wrinkles, texture, pores, UV spots, brown spots, red areas, and porphyrins before and after treatment. Lower scores indicated improved skin conditions [17].

Clinical Erythema Assessment (CEA) scale

The severity of facial erythema was evaluated using the CEA scale. Two dermatologists, independent of the study team, performed assessments before treatment and one month after the final treatment session. This CEA scale ranges from 0 to 4, with 0 representing no erythema, 1 indicating mild erythema, 2 moderate erythema, 3 marked erythema, and 4 severe erythema [18].

Skin analysis

Skin biophysical parameters were assessed before treatment and one month post-treatment using a multifunctional skin analyzer (MPA6, CK, Germany). The parameters measured included transepidermal water loss (TEWL), sebum secretion, and stratum corneum hydration. TEWL was determined using the formula: TEWL = (measured value - baseline value)/(time × area) [19].

Quality of life assessment

The Rosacea Quality of Life scale (RosaQoL) was used to assess patients' quality of life (QoL) following treatment. This scale evaluates three domains: Emotions, Function, and Symptoms. Clinical interpretation of RosaQoL scores is categorized as follows: 0-20 indicates excellent QoL, 21-40 good QoL, 41-60 moderate QoL, 61-80 poor QoL, and 81-100 very poor QoL. The RosaQoL scale demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.96 [20].

Recurrence rate

Recurrence was defined as the reappearance of erythema and/or telangiectasia, confirmed by dermatological evaluation and requiring additional therapeutic intervention [21]. Follow-up assessments were conducted at 3, 6, 12, and 18 months post-treatment. During these assessments, patients were evaluated for signs of recurrence using standardized clinical criteria, including visual examination and photographic documentation.

Statistical analysis

Statistical analyses were performed using SPSS 29.0 software (SPSS, Inc., Chicago, IL, USA). The Shapiro-Wilk test was employed to evaluate the normality of continuous data. Quantitative data were presented as mean ± SD or median (SD) for normally distributed variables, or median with interquartile range for non-normally distributed data. Between-group comparisons for normally distributed data were conducted using independent two-sample t-tests, whereas non-parametric data were analyzed using the Mann-Whitney U test. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test, as appropriate. For variables exhibiting significant group-by-time interaction effects, post hoc comparisons were performed using independent sample t-tests with Bonferroni's correction to adjust for multiple testing. A two-sided *P*-value of < 0.05 was considered statistically significant. GraphPad Prism 8.0 (GraphPad Software, La Jolla, California, USA) was adopted for graphical presentation of data. Spearman's rank correlation coefficient was employed to assess the strength and direction of associations between continuous variables and treatment outcomes. This non-parametric method was selected due to its robustness against outliers and its applicability to ordinal or non-normally distributed data.

Results

Demographic and baseline data

A total of 112 participants were enrolled and divided into three groups: PDL (n = 36), NB-IPL (n = 38), and BB-IPL (n = 38) (**Table 1**). The demographic and baseline characteristics, including age, gender distribution, body mass index (BMI), duration of disease, and comorbidities such as hypertension and diabetes, were comparable across all groups, with no statistically significant differences observed. The mean ages were (45.15 ± 1.26) years for the PDL group, (44.83 ± 1.48) years for the NB-IPL group, and (44.64 ± 1.13) years for the BB-IPL group (*P* = 0.195). Female participants constituted 69.44%, 65.79%, and 60.53% of the PDL, NB-IPL, and BB-IPL groups, respectively (*P* = 0.720). Mean BMI values were (23.48 ± 2.13), (23.14 ± 2.64), and (23.38 ± 2.35) kg/m^2 for PDL, NB-IPL, and BB-IPL groups, respectively (*P* = 0.832). Duration averaged (14.61 ± 2.23) months in the PDL group, (14.25 ± 2.13) months in NB-IPL, and (14.37 ± 2.58) months in BB-IPL (*P* = 0.775). The distribution of Fitzpatrick skin types and lesion locations was also comparable among groups. These findings

Table 1. Comparison of demographic and basic data among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
Age (years)	45.15 ± 1.26	44.83 ± 1.48	44.64 ± 1.13	1.671	0.195
Gender (Female, %)	25 (69.44%)	25 (65.79%)	23 (60.53%)	0.657	0.720
BMI (kg/m^2)	23.48 ± 2.13	23.14 ± 2.64	23.38 ± 2.35	0.185	0.832
Duration of disease (months)	14.61 ± 2.23	14.25 ± 2.13	14.37 ± 2.58	0.256	0.775
Hypertension [n (%)]	9 (25.00%)	9 (23.68%)	11 (28.95%)	0.296	0.862
Diabetes [n (%)]	8 (22.22%)	7 (18.42%)	9 (23.68%)	0.332	0.847
Smoking history [n (%)]	7 (19.44%)	9 (23.68%)	7 (18.42%)	0.361	0.835
Drinking history [n (%)]	9 (25.00%)	11 (28.95%)	13 (34.21%)	0.762	0.683
Skin types [n (%)]				-	-
Fitzpatrick II	12 (33.33%)	11 (28.95%)	13 (34.21%)		
Fitzpatrick III	15 (41.67%)	19 (50.00%)	15 (39.47%)		
Fitzpatrick IV	9 (25%)	8 (21.05%)	10 (26.32%)		
Lesion sites [n (%)]				-	-
Nasal alone	9 (25.00%)	8 (21.05%)	10 (26.32%)		
Nasal and extra-nasal	9 (25.00%)	11 (28.95%)	12 (31.58%)		
Extra-nasal alone	18 (50.00%)	19 (50.00%)	16 (42.11%)		

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; BMI, Body Mass Index.

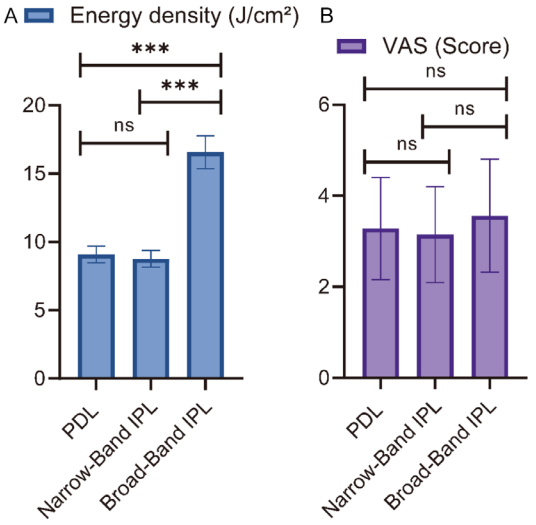

Figure 1. Comparison of treatment parameters among the three groups. A. Energy density (J/cm^2); B. Visual Analogue Scale (VAS) scores. Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light. Ns: No significant difference; ***: $P < 0.001$.

indicate that the groups were well-matched in terms of demographic and clinical characteristics.

Treatment parameters

The energy density applied in the BB-IPL group was significantly higher, at (16.57 ± 1.21) J/cm^2, compared to (9.08 ± 0.61) J/cm^2 in the PDL group and (8.76 ± 0.61) J/cm^2 in the NB-IPL group ($P < 0.001$) (**Figure 1**). Despite this difference in energy density, the VAS scores assessing treatment-related discomfort did not differ significantly among the groups, with mean scores of (3.28 ± 1.12) for PDL, (3.15 ± 1.05) for NB-IPL, and (3.56 ± 1.24) for BB-IPL ($P = 0.308$). These findings suggest that although the BB-IPL group received a significantly higher energy density, patient-reported pain or discomfort did not differ notably across all treatment modalities.

VISIA scores and clinical evaluation

Before treatment, mean VISIA scores for spots were (30.83 ± 5.87) in the PDL group, (31.28 ± 5.43) in the NB-IPL group, and (31.05 ± 5.36) in the BB-IPL group ($P = 0.941$) (**Table 2**). Similarly, wrinkle scores were comparable across groups: (12.48 ± 4.15), (12.14 ± 4.28), and (12.36 ± 4.18) for the PDL, NB-IPL, and BB-IPL groups, respectively ($P = 0.942$). Texture scores were (4.37 ± 1.21) for PDL, (4.22 ± 1.08) for the NB-IPL group, and (4.42 ± 1.13) for the BB-IPL group ($P = 0.721$), while pore measurements were (12.15 ± 4.13), (12.34 ± 5.67), and (12.24 ± 4.26) ($P = 0.986$). Scores for UV spots, brown spots, red zones, and porphyrins also demonstrated no significant baseline differences among the groups ($P > 0.05$).

Table 2. Comparison of VISIA scores before treatment and after treatment among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
Spots					
Before treatment	30.83 ± 5.87	31.28 ± 5.43	31.05 ± 5.36	0.060	0.941
After treatment	24.28 ± 4.34	23.15 ± 4.21	24.39 ± 4.16	0.988	0.377
Wrinkles					
Before treatment	12.48 ± 4.15	12.14 ± 4.28	12.36 ± 4.18	0.060	0.942
After treatment	10.58 ± 3.26	10.12 ± 3.12	10.89 ± 3.06	0.586	0.559
Texture					
Before treatment	4.37 ± 1.21	4.22 ± 1.08	4.42 ± 1.13	0.329	0.721
After treatment	3.14 ± 0.85	3.11 ± 0.67	3.23 ± 0.78	0.278	0.759
Pores					
Before treatment	12.15 ± 4.13	12.34 ± 5.67	12.24 ± 4.26	0.014	0.986
After treatment	10.24 ± 3.87	10.14 ± 3.64	10.34 ± 3.31	0.031	0.969
UV spots					
Before treatment	22.38 ± 7.26	22.16 ± 7.14	22.42 ± 7.35	0.015	0.985
After treatment	20.18 ± 6.34	19.69 ± 6.12	20.34 ± 6.65	0.111	0.895
Brown spots					
Before treatment	37.85 ± 5.43	37.68 ± 5.12	37.41 ± 5.16	0.067	0.935
After treatment	32.84 ± 5.16	32.18 ± 4.97	33.11 ± 5.08	0.341	0.712
Red zone					
Before treatment	31.84 ± 5.48	31.47 ± 5.24	31.63 ± 5.37	0.043	0.958
After treatment	21.96 ± 3.28	20.15 ± 3.32	22.68 ± 5.47	4.197	0.019
Porphyrins					
Before treatment	7.45 ± 2.16	7.14 ± 2.23	7.38 ± 2.36	0.208	0.813
After treatment	4.14 ± 1.15	3.59 ± 1.16	4.38 ± 1.34[b]	4.161	0.020

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; VISIA, Visual Imaging System for Assessing Skin; UV, Ultraviolet. b, P < 0.05 vs. NB-IPL group.

These results confirm that skin characteristics were evenly matched before treatment.

After treatment, the NB-IPL group demonstrated a significantly greater reduction in mean red zone scores (20.15 ± 3.32) compared to the BB-IPL group (22.68 ± 5.47) (P = 0.019) (**Table 2**). Likewise, porphyrin levels decreased more substantially in the NB-IPL group (3.59 ± 1.16) than in the BB-IPL group (4.38 ± 1.34; P = 0.020). No significant differences were noted among groups for other parameters including spots, wrinkles, texture, pores, UV spots, and brown spots, with P values ranging from 0.377 to 0.969. These findings indicate that while all treatments yield improvements, NB-IPL may offer superior efficacy in reducing red zones and porphyrins.

Figure 2 presents the facial features of patients with erythematotelangiectatic rosacea before and after treatment using three different therapeutic approaches. Panels A and D show a representative case treated with PDL, demonstrating a marked reduction in erythema following treatment. Panels B and E depict the effects of NB-IPL, which notably reduced visible telangiectasia and diffuse facial redness. Panels C and F illustrate the outcomes following BB-IPL treatment, indicating improvements in erythema and sebum levels, although mild post-inflammatory hyperpigmentation was observed in some patients. These visual observations align closely with the quantitative data obtained from the VISIA imaging system and clinical assessment scales described above.

Clinical Erythema Assessment (CEA) scale

Baseline CEA scores did not differ significantly among groups, with values of (3.18 ± 0.35) for the PDL group, (3.06 ± 0.31) for the NB-IPL group, and (3.11 ± 0.33) for the BB-IPL group (P = 0.297) (**Figure 3**). Post-treatment, the NB-

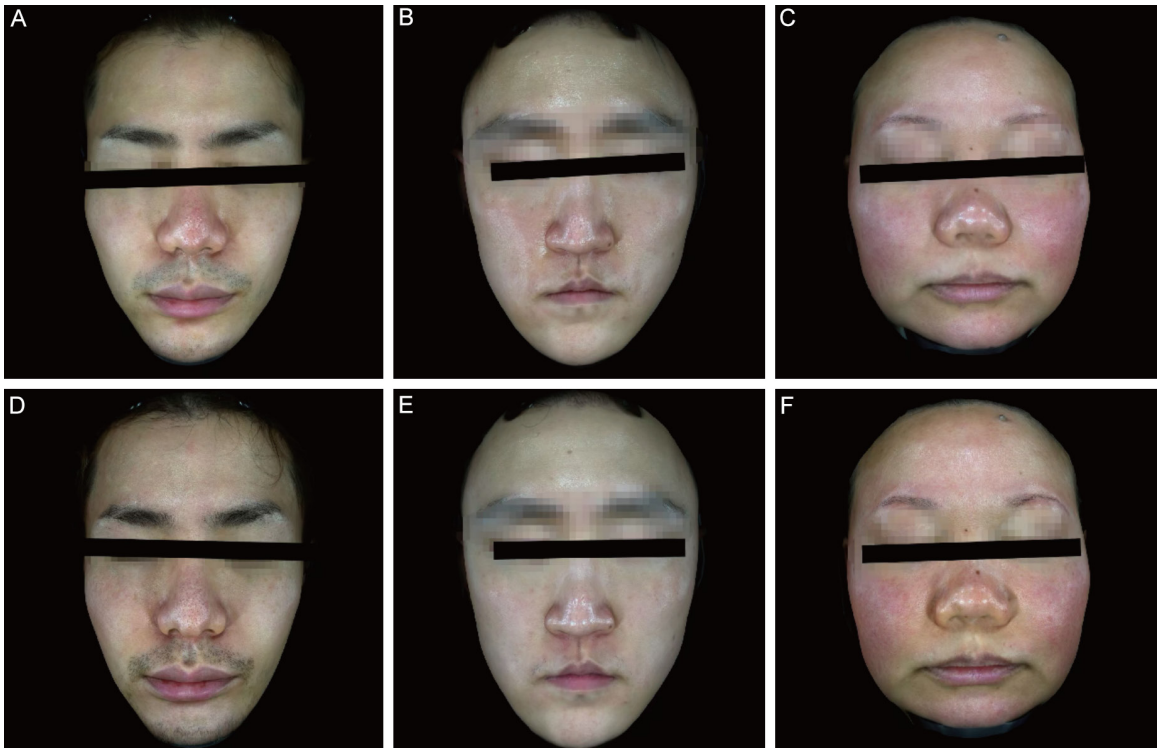

Figure 2. Facial features of patients with erythematotelangiectatic rosacea before and after treatment. A. PDL before treatment; B. Narrow-Band IPL before treatment; C. Broad-Band IPL after treatment; D. PDL after treatment; E. Narrow-Band IPL after treatment; F. Broad-Band IPL before treatment. Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light. All images have been anonymized to ensure patient confidentiality.

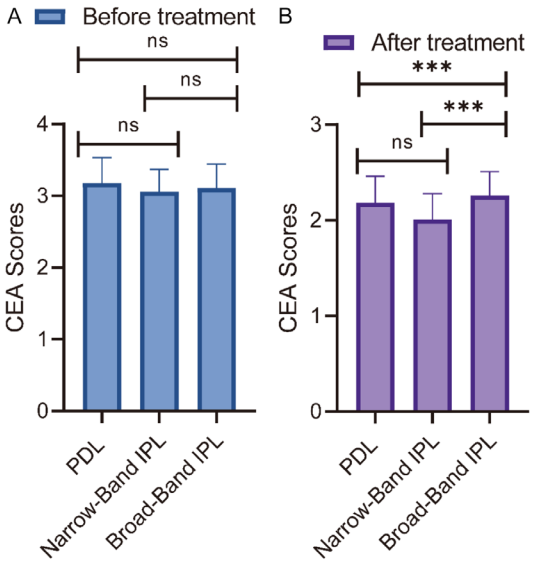

Figure 3. Comparison of CEA scores among the three groups before and after treatment. Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; CEA, Clinical Erythema Assessment. A. Before treatment; B. After treatment. Ns: No significant difference; ***: $P < 0.001$.

IPL group demonstrated the greatest improvement, achieving a significantly lower mean CEA score of (2.01 ± 0.27), compared to (2.18 ± 0.28) in the PDL group ($P < 0.05$) and (2.26 ± 0.25) in the BB-IPL group ($P < 0.001$). Additionally, the BB-IPL group's post-treatment CEA score was significantly higher than that of the NB-IPL group ($P < 0.001$). These results suggest that NB-IPL is more effective in reducing erythema in patients with ETR than PDL or broad-band IPL.

Skin physiological indicators

Baseline TEWL percentages were comparable among groups: (21.48 ± 3.26) for the PDL group, (21.16 ± 3.45) for the NB-IPL group, and (21.39 ± 3.11) for the BB-IPL group ($P = 0.916$) (**Table 3**). Sebum levels were (95.84 ± 14.12) μg/cm^2 in the PDL group, (95.43 ± 14.13) μg/cm^2 in the NB-IPL group, and (21.39 ± 3.11) μg/cm^2 in the BB-IPL group ($P = 0.985$). Stratum corneum hydration values were (43.47 ± 11.28), (44.12 ± 10.25), and (95.28 ± 14.28)

Table 3. Comparison of Skin physiological indicators before treatment and after treatment among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
TEWL (%)					
Before treatment	21.48 ± 3.26	21.16 ± 3.45	21.39 ± 3.11	0.087	0.916
After treatment	12.29 ± 2.91	12.48 ± 3.27	13.11 ± 3.14	0.718	0.491
Sebum level (μg/cm^2)					
Before treatment	95.84 ± 14.12	95.43 ± 14.13	21.39 ± 3.11	0.015	0.985
After treatment	83.24 ± 11.18	82.76 ± 11.34	70.31 ± 11.26^{aaa,bbb}	15.820	< 0.001
Stratum corneum hydration (%)					
Before treatment	43.47 ± 11.28	44.12 ± 10.25	95.28 ± 14.28	0.033	0.967
After treatment	64.19 ± 10.85	64.22 ± 10.74	68.95 ± 9.57	2.802	0.067

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light; TEWL, Transepidermal Water Loss. aaa, *P* < 0.001 vs. PDL group; bbb, *P* < 0.001 vs. Narrow-band IPL group.

Table 4. Comparison of Adverse events among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
Purpura	0 (0.00%)	0 (0.00%)	1 (2.63%)	1.965	0.374
Erythematous edema	1 (2.78%)	0 (0.00%)	0 (0.00%)	2.130	0.345
Blister	1 (2.78%)	1 (2.63%)	4 (10.53%)	3.032	0.220
Scab	2 (5.56%)	0 (0.00%)	1 (2.63%)	2.189	0.335
Pigmentation	5 (13.89%)	1 (2.63%)	8 (21.05%)^{a,b}	5.988	0.050

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light. a, *P* < 0.05 vs. PDL group; b, *P* < 0.05 vs. Narrow-band IPL group.

for PDL, NB-IPL, and BB-IPL groups, respectively (*P* = 0.967). These results confirm no significant differences in baseline skin physiological indicators across treatment groups.

Post-treatment, TEWL values remained statistically similar among groups: (12.29 ± 2.91) for PDL, (12.48 ± 3.27) for NB-IPL, and (13.11 ± 3.14) for BB-IPL (*P* = 0.491) (**Table 3**). Sebum levels significantly decreased in the BB-IPL group to (70.31 ± 11.26) μg/cm^2, which was markedly lower than in the PDL (83.24 ± 11.18 μg/cm^2) and NB-IPL groups (82.76 ± 11.34 μg/cm^2) (*P* < 0.001). Stratum corneum hydration increased across all groups, with values of (64.19 ± 10.85) for PDL, (64.22 ± 10.74) for NB-IPL, and (68.95 ± 9.57) for the BB-IPL group; however, these differences did not reach statistical significance (*P* = 0.067). These results indicate that BB-IPL significantly reduces sebum secretion more effectively than the other modalities examined.

Adverse events

No cases of purpura were observed in the PDL or NB-IPL groups, whereas 1 patient (2.63%) in the BB-IPL group experienced purpura (*P* = 0.374) (**Table 4**). Erythematous edema was noted in 1 patient (2.78%) in the PDL group, with none reported in the other groups (*P* = 0.345). The incidence of blistering was 2.78% (n = 1) in the PDL group, 2.63% (1) in the NB-IPL group, and 10.53% (4) in the BB-IPL group (*P* = 0.220). Scabbing occurred in 2 patients (5.56%) in the PDL group and 1 patient (2.63%) in the BB-IPL group, with none in the BB-IPL group (*P* = 0.335). Notably, pigmentation changes were more frequent in the BB-IPL group (n = 8, 21.05%) than in the PDL group (n = 5, 13.89%), and significantly higher compared to the NB-IPL group (n = 1, 2.63%), with a borderline statistical significance (P = 0.050). These results suggest a greater risk of pigmentation changes following BB-IPL treatment relative to the other modalities.

Quality of life assessment

Significant differences among groups were observed in the Emotions and Symptoms domains of the Rosacea Quality of Life scale (P < 0.05), while no significant difference was found in the Function domain (P > 0.05) (**Table 5**). The PDL

Table 5. Comparison of patients' rosacea quality of life scale among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
Emotions	47.42 ± 7.83	43.25 ± 5.66[a]	44.54 ± 6.65		< 0.05
Function	26.82 ± 2.73	25.24 ± 3.25	26.25 ± 2.89		> 0.05
Symptoms	36.25 ± 4.09	33.64 ± 3.29[aa]	35.36 ± 4.12		< 0.05

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light. a, $P < 0.05$ vs. PDL group; aa, $P < 0.01$ vs. PDL group.

Table 6. Comparison of patients' recurrence rates among the three groups

Parameters	PDL group (n = 36)	Narrow-Band IPL Group (n = 38)	Broad-Band IPL Group (n = 38)	W	P
Follow-up month					
3	2 (5.56%)	2 (5.26%)	2 (5.26%)		
6	2 (5.56%)	1 (2.63%)	1 (2.63%)		
12	1 (2.78%)	0 (0.00%)	1 (2.63%)		
18	0 (0.00%)	0 (0.00%)	0 (0.00%)		
Total	5 (13.89%)	3 (7.89%)	4 (10.53%)		> 0.05

Note: PDL, Pulsed Dye Laser; IPL, Intense Pulsed Light.

Table 7. Correlation analysis of the efficacy and safety of the PDL group and Narrow-band IPL group for erythematotelangiectatic rosacea

Parameters	rho	P
Red zone-After treatment	-0.228	0.051
Porphyrins-After treatment	-0.221	0.059
CEA scale-After treatment	-0.280	0.016
Energy density (J/cm^2)	-0.236	0.043
RosaQoL-Emotions	-0.353	0.002
RosaQoL-Function	-0.263	0.023
RosaQoL-Symptoms	-0.333	0.004

Note: CEA, Clinical Efficacy Assessment; RosaQoL, Rosacea Quality of Life scale.

group reported higher Emotions scores (47.42 ± 7.83) compared to the NB-IPL group (43.25 ± 5.66, P < 0.05), whereas the BB-IPL group (44.54 ± 6.65) did not differ significantly from either. For Symptoms, the NB-IPL group scored significantly lower (indicating better outcomes) than the PDL group (33.64 ± 3.29 vs. 36.25 ± 4.09, P < 0.01), while the BB-IPL group (35.36 ± 4.12) showed no statistical difference. Fun ction scores were similar across all groups (PDL: 26.82 ± 2.73; NB-IPL: 25.24 ± 3.25; BB-IPL: 26.25 ± 2.89).

Recurrence

Recurrence rates of erythematotelangiectatic rosacea were evaluated across the PDL, NB-IPL, and BB-IPL groups during an 18-month follow-up period (**Table 6**). Overall recurrence rates were 13.89% for the PDL group, 7.89% for the NB-IPL group, and 10.53% for the BB-IPL group, with no statistically significant differences among groups (P > 0.05). At 3 months post-treatment, recurrence rates were comparable across all groups at approximately 5%. By 6 months, the IPL groups exhibited a slightly lower recurrence rate (2.63%) compared to the PDL group (5.56%), a trend that persisted at 12 months with recurrence rates ranging from 0% to 2.78%. No recurrences were observed in any group at the 18-month follow-up.

Correlation analysis of the efficacy and safety of three treatment methods for erythematotelangiectatic rosacea

A negative correlation approaching statistical significance was observed between post-treatment red zone measurements and the assessed parameters (-0.228; $P = 0.051$) (**Table 7**). Similarly, porphyrin levels after treatment showed a trend toward a negative correlation (-0.221; $P = 0.059$). In contrast, significant negative correlations were identified between the CEA score after treatment and treatment outcomes (-0.280; $P = 0.016$), as well as between energy density and outcomes (-0.236; $P = 0.043$). Furthermore, strong inverse correlations were found between the RosaQoL domains - Emotions (-0.353, $P = 0.002$) and Sy-

Table 8. Correlation analysis of the efficacy and safety of the Narrow-band IPL group and Broad-band IPL group for erythematotelangiectatic rosacea

Parameters	rho	P
Red zone-After treatment	0.254	0.027
Porphyrins-After treatment	0.311	0.006
CEA scale-After treatment	0.432	< 0.001
Energy density (J/cm^2)	0.866	< 0.001
Sebum level (μg/cm^2)-After treatment	-0.491	< 0.001
Stratum corneum hydration (%)-After treatment	0.216	0.061
Pigmentation	0.285	0.013
RosaQoL-Symptoms	-0.230	0.045

Note: CEA, Clinical Efficacy Assessment; RosaQoL, Rosacea Quality of Life scale.

mptoms (-0.333, P = 0.004) - and treatment outcomes. The Function domain of RosaQoL was also inversely correlated with treatment intensity (-0.263; P = 0.023).

Post-treatment red zone measurements positively correlated with treatment outcomes (0.254; *P* = 0.027) (**Table 8**), as did porphyrin levels (0.311; *P* = 0.006). The strongest positive correlations were observed between the post-treatment CEA score and outcomes (0.432; *P* < 0.001), and between energy density and outcomes (0.866; *P* < 0.001). Sebum levels after treatment were significantly negatively correlated with outcomes (-0.491; *P* < 0.001), indicating reductions in sebum levels may be associated with improved clinical outcomes. Pigmentation changes also showed a significant positive correlation with treatment effects (0.285; *P* = 0.013), whereas stratum corneum hydration showed a non-significant positive trend (0.216; *P* = 0.061). Additionally, the RosaQoL Symptoms domain (-0.230, *P* = 0.045) showed a significant negative association with outcomes.

Discussion

In the present study, we conducted a comprehensive comparative analysis of three commonly used treatments for ETR: PDL, NB-IPL, and BB-IPL. Our aim was to evaluate their efficacy and safety, and to elucidate potential mechanisms underlying the observed clinical outcomes.

A key finding of our investigation was the superior efficacy of NB-IPL in reducing both erythema and porphyrin levels compared to PDL and BB-PDL. This aligns with previous studies, including the study by Arminda et al. (2024), which demonstrated that the specific wavelength range employed by NB-IPL selectively targets oxyhemoglobin, inducing effective photothermolysis of superficial cutaneous vasculature [22]. The focused energy delivery of NB-IPL likely facilitates selective vascular destruction, thereby achieving more pronounced erythema clearance. Moreover, the significant decrease in porphyrins also suggests that NB-IPL may modulate sebaceous gland activity, a recognized factor in the inflammatory pathogenesis of rosacea [13, 23, 24]. Supporting this, Huang et al. (2023) reported notable decreases in porphyrin levels following NBIPL treatment, corroborating our findings of improved porphyrin suppression in this treatment [25].

Conversely, BB-IPL employed a higher energy density, which, while advantageous for treating larger areas, may have contributed to a slightly increased incidence of adverse events, particularly pigmentation changes. The broad wavelength spectrum of BB-IPL enables penetration at multiple depths and targets various chromophores. However, this lack of selectivity can result in unintended photothermal damage to melanin, potentially causing post-inflammatory hyperpigmentation [26]. Cai et al. (2022) similarly reported that the wide spectral range of BB-IPL can induce non-selective photothermal damage, corroborating our findings of increased pigmentation changes in this treatment group [27]. Despite this drawback, BB-IPL demonstrated significant efficacy in reducing sebum levels, aligning with its documented effects on sebaceous gland size and activity - key contributors to rosacea pathogenesis [12, 28]. This profile suggests BB-IPL may be particularly suitable for patients with ETR complicated by seborrhea.

PDL, a well-established modality known for its high specificity to hemoglobin absorption, did not significantly outperform the other treatments in erythema reduction but showed comparable overall efficacy. As emphasized by Li et al. (2021) and Maeng et al. (2024), PDL's precise targeting minimizes collateral tissue

damage, which likely accounts for the lower incidence of adverse events associated with its use [29, 30]. The similarity in VISIA and CEA scores across groups post-treatment suggests that while all modalities are effective, treatment selection can be guided by patient-specific factors such as skin type and individual preferences.

The study was designed with three groups to enable a comprehensive comparison of the efficacy and safety profiles of different treatments for ETR. The PDL group was included to evaluate its specificity in targeting hemoglobin and reducing erythema while minimizing adverse effects. The NB-IPL group aimed to evaluate its effectiveness in selectively targeting oxyhemoglobin, leading to pronounced thermocoagulation of superficial vasculature. The BB-IPL group was investigated for its ability to reduce sebum production and treat larger treatment areas, albeit with a slightly higher incidence of adverse events. By comparing these three modalities, we sought to identify the optimal balance of efficacy and safety across different patient subgroups, thereby providing clinicians with evidence to tailor therapy according to individual patient characteristics.

The safety profile observed underscores the distinct advantages and limitations of each treatment. The minimal adverse effects associated with NB-IPL likely reflect its focused energy delivery calibrated to specific hemoglobin absorption peaks, thereby minimizing non-selective photothermal damage. PDL's favorable safety profile is consistent with its well-established hemoglobin specificity, which inherently spares melanin. In contrast, the increased incidence of pigmentation changes and blistering noted in the BB-IPL group may be attributed to its broader wavelength spectrum, leading to greater epidermal absorption and subsequent adverse effects [31, 32].

The superior efficacy of NB-IPL in improving Emotions and Symptoms domains may be attributed to its broader-spectrum photothermal effects, which target hemoglobin and the cutaneous vasculature more comprehensively than PDL, thereby effectively reducing erythema and alleviating associated psychological distress [33]. The absence of significant differences in the Function domain suggests that limitations in daily activities related to rosacea are multifactorial and may not respond sufficiently to vascular-targeted therapies alone. While NB-IPL demonstrates promise for enhancing symptom-driven quality-of-life, the relatively small sample sizes and short duration of follow-up in this study limit the generalizability of these findings. Future studies should explore dose-response relationships and consider multimodal therapeutic approaches to address functional impairments more effectively.

The observed non-significant trend toward lower recurrence rates in the IPL groups, particularly NB-IPL, may reflect its broader vascular targeting capabilities, potentially resulting in more effective suppression of inflammatory pathways implicated in rosacea pathogenesis compared to PDL [34, 35]. Nonetheless, the limited sample size and comparable long-term outcomes (0% recurrence at 18 months) suggest that recurrence risk tends to diminish over time, regardless of the treatment modality. These findings align with previous studies indicating that sustained remission in rosacea relies more on cumulative treatment effects than on differences between acute interventions [36]. Larger patient cohorts and extended follow-up periods are needed to clarify the modality-specific impacts on early recurrence dynamics.

Baseline and post-treatment VISIA system scores, alongside skin physiological parameters, provide insight into the underlying mechanisms through which these treatments exert their therapeutic effects. Notably, reductions in TEWL and increases in stratum corneum hydration observed across all groups indicate that light-based treatments may promote restoration of skin barrier function, irrespective of the device employed. This indicates that beyond targeting superficial vasculature, these interventions contribute to improving skin barrier integrity - a critical factor given the barrier dysfunction characteristic of ETR [37, 38].

The contrasting correlations between energy density and clinical outcomes among different modalities highlight important considerations in rosacea phototherapy. While IPL demonstrates dose-dependent efficacy through combined vascular targeting and modulation of sebaceous gland activity, both PDL and NB-IPL exhibit inverse relationships between treatment intensity and quality of life measures,

suggesting that overly aggressive energy parameters may induce tissue stress that counterbalances therapeutic benefits. IPL's dual efficacy on erythema reduction and bacterial porphyrin fluorescence comes with potential tolerability risks, whereas the relatively weak correlations with RosaQoL underscore the multifactorial determinants of patient quality of life in rosacea. These findings emphasize the need for modality-specific optimization of treatment parameters - favoring careful energy titration in IPL to balance vascular efficacy with cutaneous safety, while adopting more conservative protocols for PDL/IPL, particularly in patients vulnerable to psychosocial distress. Longitudinal studies are needed to clarify causal pathways and to refine personalized treatment strategies.

Ultimately, the selection of treatment modality should be guided by a comprehensive evaluation of individual patient needs and expectations. For patients prioritizing minimal discomfort and a strong safety profile, PDL remains a preferred option [39]. Conversely, in more complex cases characterized by pronounced erythema or concomitant issues such as sebum overproduction, NB-IPL or BB-IPL might offer superior therapeutic benefits due to their efficacy in addressing these aspects [13].

In evaluating the efficacy and safety of PDL, NB-IPL, and BB-IPL for treating ETR, it is crucial to acknowledge several limitations inherent to this study. The retrospective design introduces potential selection bias and restricts control over confounding variables not standardized within patient records. Variations in practitioner technique and patient compliance may have influenced treatment outcomes, while the subjective nature of assessment tools, such as VAS, adds further variability. Furthermore, although the sample size was relatively large, the predominance of Fitzpatrick skin types II to IV among participants may limit the generalizability of findings to other skin types. Despite an 18-month follow-up period, longer-term studies are necessary to fully understand the durability of treatment effects and recurrence patterns. Nonetheless, this study provides valuable real-world insights into these commonly used treatment modalities. Future prospective studies with larger cohorts and rigorous control of confounding factors - including the psychological impact of rosacea and its treatment - are warranted.

Conclusion

In conclusion, although several treatment modalities are available for ETR, our study highlights the distinct advantages associated with each. NB-IPL demonstrates superior efficacy in reducing erythema, BB-IPL effectively regulates sebaceous gland activity, and PDL provides a well-balanced and safe option suitable for broad clinical application. These findings emphasize the importance of individualized treatment selection, enabling clinicians to optimize both therapeutic efficacy and safety in managing this chronic and often challenging condition.

Disclosure of conflict of interest

None.

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References

[1] van Zuuren EJ, Arents BWM, van der Linden MMD, Vermeulen S, Fedorowicz Z and Tan J. Rosacea: new concepts in classification and treatment. Am J Clin Dermatol 2021; 22: 457-465.

[2] Cho M, Woo YR, Cho SH, Lee JD and Kim HS. Metformin: a potential treatment for acne, hidradenitis suppurativa and rosacea. Acta Derm Venereol 2023; 103: adv18392.

[3] Geng RSQ, Bourkas AN, Mufti A and Sibbald RG. Rosacea: pathogenesis and therapeutic correlates. J Cutan Med Surg 2024; 28: 178-189.

[4] Kang CN, Shah M and Tan J. Rosacea: an update in diagnosis, classification and management. Skin Therapy Lett 2021; 26: 1-8.

[5] Paiva-Santos AC, Gonçalves T, Peixoto D, Pires PC, Velsankar K, Jha NK, Chavda VP, Mohammad IS, Cefali LC, Mazzola PG, Mascarenhas-Melo F and Veiga F. Rosacea topical treatment and care: from traditional to new drug delivery systems. Mol Pharm 2023; 20: 3804-3828.

[6] Rodrigues-Braz D, Zhao M, Yesilirmak N, Aractingi S, Behar-Cohen F and Bourges JL. Cutaneous and ocular rosacea: common and specific physiopathogenic mechanisms and study models. Mol Vis 2021; 27: 323-353.

[7] Searle T, Al-Niaimi F and Ali FR. Rosacea. Br J Hosp Med (Lond) 2021; 82: 1-8.

[8] Sharma A, Kroumpouzos G, Kassir M, Galadari H, Goren A, Grabbe S and Goldust M. Rosacea management: a comprehensive review. J Cosmet Dermatol 2022; 21: 1895-1904.
[9] Shi H, Zhang E, Zhang M and Lin T. Narrowband intense pulsed light as treatment for erythematotelangiectatic rosacea: a retrospective study. J Drugs Dermatol 2023; 22: 1095-1098.
[10] Chang HC and Chang YS. Pulsed dye laser versus intense pulsed light for facial erythema of rosacea: a systematic review and meta-analysis. J Dermatolog Treat 2022; 33: 2394-2396.
[11] Jiang P, Liu Y, Zhang J, Liu Y, Li M, Tao M, Zhang Y, Tang Z, Liu W and Xu Y. Mast cell stabilization: new mechanism underlying the therapeutic effect of intense pulsed light on rosacea. Inflamm Res 2023; 72: 75-88.
[12] Husein-ElAhmed H and Steinhoff M. Light-based therapies in the management of rosacea: a systematic review with meta-analysis. Int J Dermatol 2022; 61: 216-225.
[13] Ruan J, Zheng Y and Cai S. Efficacy and safety comparison between pulsed dye laser and intense pulsed light configured with different wavelength bands in treating erythematotelangiectatic rosacea. Lasers Med Sci 2024; 39: 146.
[14] Chernyshov PV, Finlay AY, Tomas-Aragones L, Steinhoff M, Manolache L, Pustisek N, Dessinioti C, Svensson A, Marron SE, Bewley A, Salavastru C, Dréno B, Suru A, Koumaki D, Linder D, Evers AWM, Abeni D, Augustin M, Salek SS, Nassif A, Bettoli V, Szepietowski JC and Zouboulis CC. Quality of life measurement in rosacea. Position statement of the European academy of dermatology and venereology task forces on quality of life and patient oriented outcomes and acne, rosacea and hidradenitis suppurativa. J Eur Acad Dermatol Venereol 2023; 37: 954-964.
[15] Schaller M, Almeida LMC, Bewley A, Cribier B, Del Rosso J, Dlova NC, Gallo RL, Granstein RD, Kautz G, Mannis MJ, Micali G, Oon HH, Rajagopalan M, Steinhoff M, Tanghetti E, Thiboutot D, Troielli P, Webster G, Zierhut M, van Zuuren EJ and Tan J. Recommendations for rosacea diagnosis, classification and management: update from the global ROSacea COnsensus 2019 panel. Br J Dermatol 2020; 182: 1269-1276.
[16] Naunheim MR, Dai JB, Rubinstein BJ, Goldberg L, Weinberg A and Courey MS. A visual analog scale for patient-reported voice outcomes: the VAS voice. Laryngoscope Investig Otolaryngol 2019; 5: 90-95.
[17] Pan Y, Jia K, Yan S and Jiang X. Effectiveness of VISIA system in evaluating the severity of rosacea. Skin Res Technol 2022; 28: 740-748.
[18] Tan J, Liu H, Leyden JJ and Leoni MJ. Reliability of clinician erythema assessment grading scale. J Am Acad Dermatol 2014; 71: 760-763.
[19] Xiao P and Chen D. The effect of sun tan lotion on skin by using skin TEWL and skin water content measurements. Sensors (Basel) 2022; 22: 3595.
[20] Salleras Redonnet M, del Pozo Losada J and Ribera Pibernat M. [Translated article] Cross-cultural validation of the RosaQol scale in spanish language. Actas Dermosifiliogr 2024; 115: T858-T866.
[21] Parish LC. Andrews' diseases of the skin: clinical dermatology. JAMA 2011; 306: 213-213.
[22] Arminda A. Intense Pulsed Light (IPL) for the treatment of vascular and pigmented lesions. J Cosmet Dermatol 2024; 23 Suppl 1: 1-6.
[23] Tirico MCCP, Jensen D, Green C and Ross EV. Short pulse intense pulsed light versus pulsed dye laser for the treatment of facial redness. J Cosmet Laser Ther 2020; 22: 60-64.
[24] Chen A, Choi J, Balazic E, Zhu TR and Kobets K. Review of laser and energy-based devices to treat rosacea in skin of color. J Cosmet Laser Ther 2024; 26: 43-53.
[25] Huang C, Zhuo F, Han B, Li W, Jiang B, Zhang K, Jian X, Chen Z, Li H, Huang H, Dou X and Yu B. The updates and implications of cutaneous microbiota in acne. Cell Biosci 2023; 13: 113.
[26] Siperstein R and Wikramanayake TC. Intense pulsed light as a treatment for senile purpura: a pilot study. Lasers Surg Med 2021; 53: 926-934.
[27] Cai Y, Zhu Y, Wang Y and Xiang W. Intense pulsed light treatment for inflammatory skin diseases: a review. Lasers Med Sci 2022; 37: 3085-3105.
[28] Martignago CCS, Bonifacio M, Ascimann LT, Vassão PG, Parisi JR, Renno AP, Garcia LA, Ribeiro DA and Renno ACM. Efficacy and safety of intense pulsed light in rosacea: a systematic review. Indian J Dermatol Venereol Leprol 2024; 90: 599-605.
[29] Li Y and Wang R. Efficacy comparison of pulsed dye laser vs. microsecond 1064-nm neodymium:yttrium-aluminum-garnet laser in the treatment of rosacea: a meta-analysis. Front Med (Lausanne) 2022; 8: 798294.
[30] Maeng JE, Son SW, Lee SJ, Kim JC, Kim S, Kang HY and Park YJ. Pulsed-dye laser as an effective treatment for recalcitrant granulomatous rosacea and a potential regulator of CXCL9 expression. J Dermatol 2024; 51: 722-726.
[31] Osman M, Shokeir HA, Hassan AM and Atef Khalifa M. Pulsed dye laser alone versus its combination with topical ivermectin 1% in treatment of Rosacea: a randomized compara-

tive study. J Dermatolog Treat 2022; 33: 184-190.
[32] Park S, Jang H, Seong SH, Kim JY, Lee EJ, Bae YJ, Ahn YJ, Kim J and Oh SH. The effects of long-pulsed alexandrite laser therapy on facial redness and skin microbiota compositions in rosacea: a prospective, multicentre, single-arm clinical trial. Photodermatol Photoimmunol Photomed 2024; 40.
[33] Jiang J, Yang X, Du F, Zheng W and Yang Y. Therapeutic effect of intense pulsed light on different types of chalazion in children. Sci Rep 2024; 14: 3645.
[34] Jiang P, Liu Y, Zhang J, Liu Y, Li M, Tao M, Zhang Y, Tang Z, Liu W and Xu Y. Mast cell stabilization: new mechanism underlying the therapeutic effect of intense pulsed light on rosacea. Inflamm Res 2023; 72: 75-88.
[35] Piccolo D, Fusco I, Zingoni T and Conforti C. Effective treatment of rosacea and other vascular lesions using intense pulsed light system emitting vascular chromophore-specific wavelengths: a clinical and dermoscopical analysis. J Clin Med 2024; 13: 1646.
[36] Chen C, Wang P, Zhang L, Liu X, Zhang H, Cao Y, Wang X and Zeng Q. Exploring the pathogenesis and mechanism-targeted treatments of rosacea: previous understanding and updates. Biomedicines 2023; 11: 2153.
[37] Al-Niaimi F, Glagoleva E and Araviiskaia E. Pulsed dye laser followed by intradermal botulinum toxin type-A in the treatment of rosacea-associated erythema and flushing. Dermatol Ther 2020; 33: e13976.
[38] Park S, Lee JH, Kang E, Kim H, Kim JY, Lee EJ, Bae YJ, Kim J and Oh SH. A randomized split-face comparative study of long-pulsed alexandrite plus low-fluence Nd:YAG laser versus pulsed-dye laser in the treatment of rosacea. Lasers Surg Med 2022; 54: 1217-1225.
[39] Geng R, Bourkas AN and Sibbald RG. Rosacea: clinical aspects and treatments. Adv Skin Wound Care 2023; 36: 626-634.