

RESEARCH ARTICLE

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Efficacy and safety of Picosecond ND: YAG laser in the treatment of post-acne erythema by comparison of 1064 nm picosecond micro-lens array vs 595 nm picosecond waves: split face clinical study

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Abstract

Objective: To assess the efficacy and safety of two picosecond-laser wavelengths, 1064 nm neodymium-doped yttrium aluminium garnet with a micro-lens array and 595 nm, in the treatment of PAE using a split-face design.

Methods: Each of them received three sessions of Picosecond laser every two weeks using two Handpieces, the short wave fractional 1064 nm applied to the right side of the face, and the 595 nm dye picosecond handpiece used for the left side of the face. All the patients were observed through multiple photos taken before, during, and two months after the last session.

Results: Treatment with both wavelengths demonstrated significant ($p < 0.05$) reductions in erythema. Still, the comparison of results between left and right laser treatments revealed that the larger mean difference (1.750) for the right side compared to the left side (1.200) suggests that the laser treatment had a more substantial effect on reducing right clinician erythema assessment scores ($p = 0.0001$). No severe adverse events were reported, highlighting the safety of both modalities.

Conclusion: The micro-lens array 1064 nm handpiece of the picosecond laser demonstrated superior efficacy compared to the short pulse 595 nm handpiece for treating post-acne erythema (PAE). The picosecond laser also exhibited an excellent safety profile with minimal adverse effects, making it a valuable and recommended treatment modality for PAE management.

Keywords: Post-acne erythema, Acne scars, Acne, Picosecond-laser, Fractional picosecond-laser

Plain English Summary

This study evaluated two different laser therapy approaches for post-acne erythema (PAE), a persistent red appearance that remains after acne clears up. 20 patients received laser treatments on both sides of their face using different wavelengths - a 1064 nm laser with micro-lens array on the right side and a 595 nm laser on the left side. Each patient had 3 treatment sessions, 2 weeks apart. Two independent dermatologists evaluated the results by comparing photos taken before, during, and 2 months after therapy.

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The 1064 nm picosecond laser with micro-lens array is more effective than the 595 nm laser for treating post-acne redness, while maintaining a good safety profile. This makes it a valuable treatment option for people dealing with persistent redness after acne.

Introduction

The prevalence of acne vulgaris in the general population is approximately 9.4%, with the most significant impact seen in adolescents and young adults, where the prevalence reaches up to 85%. It is a disease of the hair follicle and sebaceous gland with several causative factors; it is one of the most common skin ailments (1). Acne is a skin condition where a myriad of skin lesions, for example, comedones and papules, occur as a response to inflammatory mediators, particularly in areas with dense sebaceous follicles like the face, chest, and upper back (2). While most individuals benefit from treatment for the active inflammatory phase, significant psychological issues and reduced quality of life arise from the persistent erythema, hyperpigmentation, and scarring changes. Although these changes are common after inflammation, PAE results in changes of cosmetically relevant stubborn erythema at the sites of previous acne lesions, which results in capillary dilatation and thinning of the epidermis and continuous release of inflammatory cytokines. It hence poses a unique therapeutic difficulty (3). The prevalence of PAE among patients with a history of moderate to severe acne is estimated to be as high as 80%, which indeed poses a significant clinical concern in dermatological practice (4).

Persistent facial erythema has also been shown to be associated with diminished self-esteem, which leads to withdrawal from social activities; therefore, PAE is an essential indicator of the need to develop effective treatment interventions for this condition, as explained by (5). They add that successfully treating PAE has the potential to significantly improve the quality of life and overall well-being of the patient.

Conventional therapies to treat PAE focus mainly on topical treatment (brimonidine tartrate, azelaic acid, and vitamin C) and light/laser-based therapies, which need to be continuously reapplied for improvement to be maintained. More traditional laser therapies, such as "pulsed dye laser (PDL)" and "intense pulsed light (IPL)" have shown some variation in effectiveness. However, concerns regarding "post-inflammatory hyperpigmentation", particularly in patients with darker skin types, have limited their widespread adoption (6).

Nonetheless, a significant gap exists in the literature because there are no direct comparative studies of these two modalities for the treatment of

PAE. The progress of "picosecond-laser technology" has modernised the practice of dermatological lasers. In contrast to older nanosecond lasers, picosecond lasers deliver ultra-short pulse durations in the picosecond range (10^{-12} seconds), causing much more significant peak powers and applying mainly photomechanical forces, as opposed to thermal, to the targeted tissues. This action can be beneficial for treating some vascular lesions like PAE because of the lower chances of thermal damage and possibly more effective vascular structure targeting (7).

Among picosecond lasers, two wavelengths have been notably effective in treating vascular lesions. These are the 1064 nm neodymium-doped yttrium aluminium garnet (ND: YAG) laser with micro-lens array (MLA) technology and the 595 nm picosecond wavelength.

The 1064 nm wavelength has a deeper penetration into the dermis with less absorption by melanin, which can be safer for patients with darker skin types. On the other hand, the 595 nm wavelength's proximity to the absorption peak of oxyhaemoglobin makes it more useful for vascular targets (8). However, no head-to-head clinical comparison between 1064 nm MLA and 595 nm picosecond handpieces has been reported, creating a significant gap in the current literature; hence, the present study was split-face designed to compare 1064 nm picosecond micro-lens array versus 595 nm picosecond waves.

Materials and Methods

Study design

This prospective, split-face clinical trial enrolled 20 patients randomly selected, aged between 15 and 35 years, having Fitzpatrick skin types II–IV with moderate to severe PAE. The study was conducted at the Duhok Dermatology Teaching Centre, located in Duhok City Centre, from February 2024 to February 2025.

Treatment Protocol

A total of 20 patients of both sexes (14 female, 6 male) were randomly selected for this study. The inclusion criteria included any patient with PAE lasting more than 3 months, regardless of whether they had new active acne lesions or not. Concurrent use of topical or systemic antibiotics before or after the procedure was permitted. The exclusion criteria included Pregnancy, breastfeeding, use of systemic or topical

Isotretinoin or steroids within the last month, any facial procedure done within the past three months, age below 10 years, phobia of darkness or wearing laser glasses, and photodermatitis (congenital, acquired, or autoimmunity).

All patients received three sessions of Picosecond-laser therapy at two-week intervals. Two Handpieces were used: the short-wave MLA fractional 1064 nm handpiece used for the right side of the face, and the 595 nm dye picosecond handpiece used for the left side of the face. This protocol was fixed. Observations were made using multiple photographs taken by a smartphone before the procedure, during the treatment, and two months after the final therapeutic session.

Intervention

All the subjects cleansed their face before the procedure, and all of them received topical anaesthesia (lidocaine 10.56%) 30 minutes before the procedure. The device used was PICOCARE

450 (Picosecond ND: YAG) laser from WONTECH CO., LTD. For the right side of the face, the HEXA MLA handpiece was used, spot size (5 mm), Fluence (3.1 J/Cm²), frequency (7), with two passes. On the left side, a 595nm dye handpiece was used with a spot size of 3mm, Fluence (1.5 J/Cm²), frequency (5), with two passes.

Outcome measures

The collected data were assessed using the reliable clinical erythema scale for facial erythema (Table 1), namely "Clinician's Erythema Assessment (CEA)" (9), and analysed with a special software program utilising IBM SPSS Inc.'s version 28.0.1.1. Two dermatologists who were not involved in the study contributed to the clinical response via CEA. The primary outcome is a decrease in Clinician's Erythema Assessment. The secondary outcome is patient satisfaction scores and the prevalence of adverse events.

Table 1. Clinician Erythema Assessment scale

| Grade | CEA Scale Description |
|-----------------|-----------------------------------|
| 0, Clear | Clear skin (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 |

The results comparison between left and right laser treatments revealed that the larger mean difference (1.750) for the right side compared to the left side (1.200) suggests that the laser treatment had a more substantial effect on reducing "Right CEA" scores. Additionally, the higher t-value (9.200) for the right side indicates a stronger statistical signal supporting this reduction.

Statistical analysis

Before applying statistical tests, data distribution normality was assessed using the Shapiro-Wilk test. Sample size was determined using power analysis with the following parameters: $\alpha = 0.05$, power = 80%. The data underwent statistical analysis through paired t-tests and analysis of variance (ANOVA). Statistical significance was

established at $p < 0.05$. The statistical computations were analysed using IBM SPSS Statistics for Windows, Version 28.0.1.1. Complete case analysis with participants excluded if they missed the last observation carried forward.

Results

Participant characteristics

The demographics of the participants enrolled in this prospective study are presented in Table 2. 20 participants enrolled (age 20.45 years), and 70% of the participants were female. The Fitzpatrick skin type classification showed that 35% of candidates had Type II skin, 60% had Type III, and 5% had Type IV, indicating that most patients had moderate skin pigmentation.

Table 2. Participants' demographics enrolled subjects

| Variables | n (%) |
|------------------------------|--------------|
| Age, mean ± SD (years) | 20.45±4.30 |
| Sex | n (%) |
| Female | 14(70) |
| Male | 6(30) |
| Fitzpatrick skin type | n (%) |
| II | 7(35) |

| | |
|-----|--------|
| III | 12(60) |
| IV | 1(5) |

Safety and adverse events

As part of the safety assessment, erythema was reported in 16 participants (80%), making it the most common side effect, while burning sensation was experienced by 4 participants (20%). Pain

levels, assessed using the Visual Analogue Scale (VAS), indicated that 60% participants experienced mild pain, whereas 40% reported moderate to severe pain (Table 3).

Table 3. Variables of the assessment scale

| Safety assessment scale | n (%) |
|-------------------------|--------|
| Erythema | 16(80) |
| burning sensation | 4(20) |
| Visual Analogue Scale | n (%) |
| mild pain | 12(60) |
| moderate-severe pain | 8(40) |

Clinical outcomes: CEA right versus left

To assess the impact of laser therapy on clinical erythema assessment (CEA), paired samples t-tests were performed to compare measurements taken before and after treatment on both facial sides. The statistical analysis examined CEA score changes following laser intervention for the right and left sides of the face. Results from the paired samples t-test revealed that "Right CEA" scores

showed a mean reduction of 1.75 points following laser therapy. The number 1.75 represents the average amount of reduction in the scores. For the right side, the mean difference in CEA scores before and after laser treatment was 1.75 ± 0.851 , with a t-value of 9.200 ($p < 0.001$), indicating a statistically significant reduction in erythema following the intervention (Figure 1).

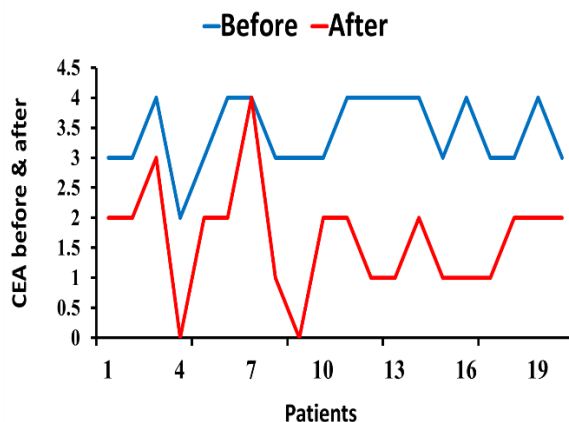


Figure 1: CEA for the right side of the face, before & after Laser treatment.

Baseline CEA scores were similar between sides (Right: 3.4 ± 0.6 ; Left: 3.15 ± 0.7). Following three laser sessions, CEA scores were significantly reduced on both sides (Right: 1.65 ± 0.94 ; Left: 1.95 ± 0.6). The mean reduction in CEA score was

substantially greater on the right side treated with the 1064 nm MLA laser (1.75 ± 0.85) compared to the left side treated with the 595 nm laser (1.20 ± 0.62) ($p < 0.001$, paired t-test) (Table 4 and Figures 2 and 3).

Table 4. Paired Samples t-test Results for Clinician Erythema Assessment (CEA) Scores.

| Side | Before | After | the p-value |
|-------|-----------------|-----------------|-------------|
| Right | 3.40 ± 0.60 | 1.65 ± 0.94 | 0.0001 |
| Left | 3.15 ± 0.70 | 1.95 ± 0.60 | 0.0001 |

Right side (1064 nm) CEA score before and after treatment.
Left side (595 nm) CEA score before and after treatment.

Data presented as Mean ± Standard Deviation, $p < 0.0001$ for all comparisons using paired t-test, Confidence interval 95%

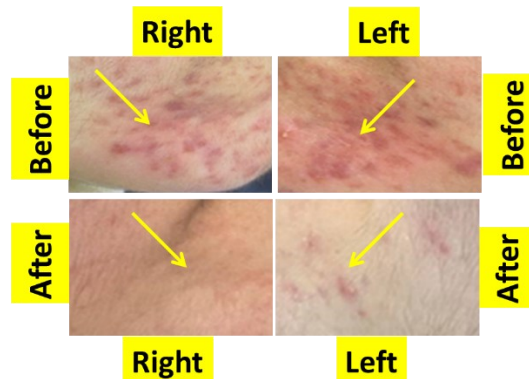


Figure 2: 15-year-old female with PAE-CEA grade four on both sides before treatment, after 3 sessions of Picosecond. Both sides show a significant decrease in CEA; the right side shows a better response with improvement in skin texture (RED arrows)



Figure 3: 23-year-old Female with PAE, CEA grade 3 on both sides before treatment, after 3 sessions of Picosecond-laser. Each side shows a significant decrease in erythema, CEA grade 0; the right side shows a better response with improvement of skin texture

Patient satisfaction

In terms of patient satisfaction, 20% reported being very satisfied, and 80% were partially pleased with the treatment (Table 5).

Table 5. Patient satisfaction score

| patient satisfaction score | n (%) |
|----------------------------|--------|
| very satisfied | 4(20) |
| partially satisfied | 16(80) |

Discussion

This study contributes to the field of laser therapy in different dermatological conditions. The precise mechanism of PAE is unclear; some consider it to be related to the wound healing processes following acne and is associated with the dilatatory changes in the microvascular structures in the dermis. The microvascular structures have a reddish colouration. During the healing phase, the epithelium becomes thinner, permitting the

reflection of light off the dilated microvasculature with ease, as stated by (10). In addition to that, they found that light and laser-based devices were among the most frequent treatments used, specifically the ND: YAG laser. Haemoglobin is the main target for vascular lesions like PAE, with excellent absorption maxima at roughly 418, 542, and 577 nm (11). The haemoglobin within dilated blood vessels serves as the laser target, which causes the dilated vessels to constrict and lessen

the visible erythema. To further aid in clinical improvement, several laser modalities may also induce skin remodelling and modulate inflammatory processes (6). Pulse dye laser (595 nm) demonstrated efficacy and high patient satisfaction as an additional intervention for post-comedone extraction, erythema reduction, and comedone removal (12). The fractional picosecond 1064 nm laser on Chinese patients with PAE revealed that it is safe and effective (8).

In our study, the comparison was between picosecond ND: YAG, using two Handpieces: 1064 MLA picosecond on the right side of the face and 595 nm dye picosecond Handpiece on the left side. The findings of this study revealed that both modalities of the treatment are active and harmless, with the 1064 MLA picosecond treatment exhibiting superior efficacy in reducing erythema and enhancing lesion texture compared to the 595 nm dye Handpiece picosecond treatment. This study provides useful evidence to assess two modalities of picosecond-laser handpieces for the same patient at the same time. The improvement is attributed to the efficacy of the Picosecond-laser 1064nm MLA, which causes a series of laser-induced optical breakdown (LIOB) in the epidermis and LIC (Intradermal laser-induced cavitation), explained in the context that LIOB and ILC cause dermal remodelling and help in the synthesis of new collagen, growth factors, and elastic fibres that could improve skin texture. Furthermore, LIOB in vascular tissue will lead to ablation or modification of vascular tissue, including PAE (13, 14).

The observed clinical improvement of PAE suggests a potential for significant positive impact on patients' quality of life, though this requires formal assessment in future studies. In addition to that, post-inflammatory erythema and acne scar become better after treatment with Alexandrite picosecond-laser compared to the non-treated side (15). Similarly, the same result found in another study done on Chinese patients with a picosecond alexandrite laser with a diffractive lens array is effective and safe for acne scars (16).

The pulse duration refinement, beam profiles, and integrated monitoring systems treatment choices for other dermatological diseases, as well as PAE, are expected to develop and improve. Together with a growing knowledge of the biological processes behind laser-tissue interactions, this holds promise for improving both the effectiveness and safety of treatments for several skin conditions.

Study limitations

The limitations of the present study, which need to be acknowledged, include a single-centre study

and a small sample size, which hinder the generalizability of the results. Limited long-term follow-up to assess the durability of treatment effects and potential delayed side effects or recurrence of erythema.

Conclusion

This split-face trial suggests that the 1064 nm picosecond MLA handpiece is more effective than the 595 nm picosecond handpiece for post-acne erythema, with both showing good safety. Larger, multi-centre trials with longer follow-up are needed to confirm these findings.

Abbreviations:

PAE: Post-Acne Erythema

MLA: Micro-lens Array

NDYAG: Neodymium-doped Yttrium Aluminium Garnet

CEA: Clinician Erythema Assessment

LIOB: Laser-induced Optical Breakdown

PDL: Pulsed Dye Laser

IPL: Intense Pulsed Light

Declarations

Ethical approval and consent to participate

Ethical approval was obtained from the Kurdistan Higher Council of Medical Specialities (Order Approval Letter 349 on 15 Feb 2024), and a written informed consent form was obtained from all patients above 18 years old, and from the parents of patients below 18 years old, before the procedure.

Consent for publication

All the author(s) gave consent for the publication of the work under the Creative Commons Attribution-Non-Commercial 4.0 license.

Availability of data and materials

The data and materials associated with this review will be made available by the corresponding author upon reasonable request.

Conflict of Interest

The authors declare no conflict of interest.

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Author's contributions

AHSK conceptualised and designed the study, supervised data acquisition, and contributed to the interpretation of results and manuscript drafting. QDS participated in patient recruitment, data collection, and laboratory analysis of serum

biomarkers. QDS also assisted in data entry and preliminary statistical analysis. SBK contributed to the literature review, data validation, and preparation of figures and tables. SBK critically reviewed the manuscript for clarity and scientific accuracy. All authors read and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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