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Efficacy and Safety of Solid-state Dual-wavelength Lasers for the Treatment of Moderate-to-severe Inflammatory Acne in Asian Populations

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Background: Standard treatments for moderate-to-severe acne often require oral medications but are not long-lasting or free from side effects. We aimed to evaluate the efficacy and safety of a solid-state dual-wavelength laser for moderate-to-severe inflammatory acne in an Asian population.

Methods: Forty individuals with moderate-to-severe acne received nightly topical retinoids and two to three weekly treatments with a 1319-nm laser followed by a 589-nm laser (five sessions in total). Patients were evaluated at pretreatment baseline, at monthly intervals, and at 1 month after the last laser for pain, seborrhea, global aesthetic improvements, and satisfaction, using standardized digital photography and global assessment scales. Fifteen patients had an additional evaluation 3 months after the fifth session.

Results: At 1 month, all patients (n = 40) had improved inflammatory acne counts, with 72.5% having greater than 75% reduction in acne count, 7.5% having 51%–75% reduction, 17.5% having 26%–50% reduction and 2.5% having less than 25% reduction. Moreover, GAS evaluations showed that 62.5% of patients improved to almost clear and 37.5% to mild acne ($P = 0.0478$), while improvements were sustained in patients with 3-month follow-ups. Erythema (n = 29) improved with 65.5% of affected patients having greater than 75% reduction. Patients (n = 17) with pigmentation experienced lightening, with 52.9% of affected patients having a greater than 75% reduction. With low pain scores (mean 3.68 of 10, median 4 of 10), the treatment was well-tolerated. All patients (n = 40) reported acne improvements with 95% having much improved or very much improved, and 95% either satisfied or very satisfied.

Conclusions: Dual-wavelength lasers effectively and safely treat moderate-to-severe inflammatory acne with high patient satisfaction. It is ideal for patients who refuse or are contraindicated to oral medications, and patients with acne-associated pigmentation, erythema and seborrhea. *(Plast Reconstr Surg Glob Open 2024; 12:e5550; doi: 10.1097/GOX.0000000000005550; Published online 29 January 2024.)*

INTRODUCTION

Acne vulgaris is a chronic inflammatory skin condition that typically starts during teenage years and often persists into adulthood. Despite being a benign condition, acne causes significant psychological impact and comorbidity.[1] Patients with moderate-to-severe acne reported feelings of negative self-image, low self-esteem, depression, and even suicidal thoughts.[2] If left untreated, acne may result in postacne erythema, postinflammatory hyperpigmentation, and scarring, especially in Asian patients and those with darker skin tones (Fitzpatrick skin types III–VI). Such acne sequelae are often more distressing to patients than the active acne lesions themselves.[3]

Early and appropriate acne treatment is important for preventing psychological and physical scarring. Numerous global and regional guidelines and consensuses in the treatment of acne are available and updated periodically.[4–8] Standard-of-care treatments for moderate-to-severe acne include topical medications like retinoid, azelaic acid, and benzoyl peroxide and hormonal and oral medications such as anti-androgens, oral contraceptives, antibiotics, and isotretinoin. However, most of these modalities result in poor compliance, lack of durable remission, and have associated side effects. In recent

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years, light and energy-based treatments have become popular for treating inflammatory acne, as they cause minimal side effects, offer rapid onset of improvements, and simultaneously prevent and treat acne scars.[9] Often, they are initiated alongside standard acne treatments.

Lasers that have been studied[10–12] for treating acne include vascular-specific lasers (eg, pulse-dye lasers and 532-nm potassium titanyl phosphate lasers) and infrared lasers [eg, the 1450-nm diode laser, 1550-nm Erbium-glass laser and 1064-nm neodymium-doped yttrium aluminum garnet (Nd:YAG) laser]. These lasers target the underlying causes of acne: colonization by *Cutibacterium acnes*, sebum production, and inflammation. Other lasers are being investigated for their capacity to selectively target sebaceous glands with or without the use of gold particles.[13,14]

By targeting inflammation and the superficial cutaneous microvasculature, 589-nm wavelength lasers are safe, well-tolerated, and effective at treating both inflammatory and noninflammatory acne vulgaris,[15–18] and are also effective at reducing postacne erythema.[19–21] Through its absorption by water in the dermis, the 1319-nm wavelength laser leads to nonselective heating of the dermis, which stimulates fibroblasts and neocollagenesis, thereby improving atrophic acne scars.[22–26] Patients treated with a 1319-nm wavelength laser have reported a reduction in sebum production,[27] likely because it targets sebaceous glands.

The dual-wavelength diode laser consists of one cavity that emits a 1064-nm laser and a second cavity that emits a 1319-nm laser. Both lasers are modulated by a shared Q-switch to generate a synchronized train of light pulses. The 1064-nm and the 1319-nm light pulses are sent simultaneously through a nonlinear, lithium triborate (LBO) crystal, which combines their photonic energies to generate the 589-nm laser. We sought to evaluate the efficacy and safety of a solid-state, dual-wavelength (589-nm and 1319-nm) laser for the treatment of moderate-to-severe acne vulgaris alongside a nightly topical retinoid.

Takeaways

Question: Is the solid-state dual-wavelength laser safe and effective for moderate-to-severe inflammatory acne in Asians?

Findings: Dual-wavelength lasers effectively treat moderate-to-severe inflammatory acne with high patient satisfaction and are an ideal treatment for patients who refuse or are contraindicated to oral medications, and patients with acne-associated pigmentation, erythema, and seborrhea.

Meaning: Dual-wavelength lasers effectively and safely treat moderate-to-severe inflammatory acne in Asian patients.

MATERIALS AND METHODS

Patients

Forty healthy individuals (age range: 16–38 years) with moderate-to-severe facial acne were recruited into a prospective, single-site study. Moderate acne was defined as acne affecting more than half of the face, whereas severe acne was defined as acne affecting the whole face (Table 1). Included patients were those not on any form of acne treatment (topical, oral, or procedural) in the preceding 3 months, who refused oral acne treatments, and who complied with nightly topical application of a retinoid and daily topical application of a broad-spectrum sunscreen during the study period. The included patients also had to commit to a total of five treatments delivered at 2-week to 3-week intervals. Exclusion criteria included pregnancy or lactation, use of hormonal or contraceptive medication, use of any medication that could cause acne, and existing and active medical or dermatological conditions.

Treatment

Full-face treatments were completed within approximately 30 minutes. All patients were required to apply a topical retinoid (adapalene 0.1% or tretinoin 0.025%) at night for the duration of the study. Treatments were performed using a dual-wavelength diode laser (Advalight, Ballerup, Denmark), which combines a 589-nm wavelength-emitting laser module with a 1319-nm wavelength-emitting laser module. Patients were treated at 2-to-3-week intervals by applying the dual-wavelength diode laser across the whole face in a sequential manner, starting with the 1319-nm laser, followed by the 589-nm laser. Laser pulses were delivered within a 10-mm by 10-mm square grid scanner at repeated treatment durations of 0.25 seconds, and in a high-density, grid-filling manner, with a 15% overlap of pulses. With both wavelengths, the handpiece was used in a dynamic fashion as it was moved over the skin during the delivery of laser energy. Laser passes were made until the treatment endpoint of mild erythema was achieved. Fluences for the 1319-nm wavelength were 45–48 J per cm^2 while fluences for the 589-nm wavelength were 35–38 J per cm^2. Each laser treatment delivered a total of 900–1000 pulses per wavelength. No anesthesia was required, but an

Table 1. Assessment of Acne Severity Using the Global Evaluation Assessment Scale (GAS)

Grade 0	Clear	Residue Pigmentation and Erythema May Exist
Grade 1	Almost clear	Rare dispersed open or closed comedones and rare papules
Grade 2	Mild	Easily identifiable. Less than half the face is affected, some open or closed comedones and some papulo-pustules
Grade 3	Moderate	More than half of the face is affected. Numerous papulo-pustules, numerous open or closed comedones. One nodule may exist
Grade 4	Severe	The whole face is affected and covered with numerous papulo-pustules, open or closed comedones and rare nodules
Grade 5	Very severe acne	Very inflammatory acne covering the whole face with nodules

Table 2. Improvement in Acne Severity

	No of Subjects at Baseline (N = 40)	No of Subjects 1 Month after Last Laser (N = 40)	No of Subjects 3 Months after Last Laser (N = 15)
Severe	7	0	0
Moderate	33	0	0
Mild	0	15 (37.5%)	5 (33.3%)
Almost clear	0	25 (62.5%)	8 (53.3%)
Clear	0	0	2 (13.3%)

air-cooling device (Zimmer Medizin Systems, Irvin, Calif.) was used for some patients to increase their comfort during the laser treatment. At subsequent laser treatments, fluences were increased by 1-2 J per cm^2.

Evaluations

Patients were evaluated at every visit [at baseline, before each treatment, and at 1 month after the last (or fifth) treatment] up to a total of six visits. A subgroup of 15 patients completed an additional visit at 3 months after the last treatment. At each visit, standardized digital photographs were taken from the front and both sides of the face.

During each visit, the investigator evaluated acne severity using the acne global evaluation assessment (GAS[28]) scale (Tables 1 and 2): 0—clear, 1—almost clear, 2—mild acne, 3—moderate acne, 4—severe acne, and 5—very severe acne. At each visit, patients were assessed and counted according to reduction in inflammatory acne lesion counts (ILC; Table 3) as greater than 75% reduction, 51%–75% reduction, 26%–50% reduction, less than 25% reduction, and no change or increased. Patients were also assessed and counted according to their improvements in erythema and pigmentation (Table 4), as greater than 75% improvement, 51%–75% improvement, 26%–50% improvement, less than 25%

Table 3. Reduction in ILC

	No of Subjects 1 Month after Last Laser (N = 40)	No of Subjects 3 Months after Last Laser (N = 15)
>75% reduction	29 (72.5%)	11 (73.3%)
51%–75% reduction	3 (7.5%)	4 (26.7%)
26%–50% reduction	7 (17.5%)	0
<25% reduction	1 (2.5)	0
No change	0	0
Increased	0	0

Table 4. Improvement in Erythema and Pigmentation 1 Month after Last Laser

	No Subjects with Erythema (N = 29)	No Subjects with Pigmentation (N = 17)
>75% improvement	19 (65.5%)	9 (52.9%)
51%–75% improvement	4 (13.8%)	1 (5.9%)
26%–50% improvement	6 (20.7%)	6 (32.3%)
<25% improvement	0	1 (5.9%)
No change	0	0
Worse	0	0

Table 5. Pain Rated on 10-point Visual Analog Scale

	None					Moderate					Severe
Pain	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
No. patients	0	0	2	13	22	2	1	0	0	0	0

improvement, and no change or worse. At the second to sixth clinic visits, patients were asked about adverse events, pain [scored on the 10-point patient visual analog scale[29]; Table 5] and the level of seborrhea (scored on the 10-point seborrhea scale, 0—absence of seborrhea, 5—moderate seborrhea, 10—high presence of seborrhea). Patients also provided ratings on the Global Aesthetic Improvement Scale (GAIS; 4—very much improved, optimal cosmetic result from original condition; 3—much improved, marked improvement in appearance from original condition; 2—improved, obvious improvement in appearance from original condition; 1—no change; 0—worse than original condition), and their satisfaction scores (5—very satisfied; 4—satisfied; 3—neither satisfied nor unsatisfied; 2—unsatisfied; 1—very unsatisfied).

Statistical Analysis

The McNemar-Bowker test of symmetry was used on the aggregated (nonraw) data, and chi-squared test calculations were performed to assess statistical significance, as it is a nonparametric and extended version of the McNemar test involving more than two groups and allows the assessment of *P* values.

RESULTS

Our study enrolled 40 patients [28 female patients, 12 male patients; mean age: 23 years (range: 16–38 years)], with Fitzpatrick skin types III and V. At baseline, 33 patients had moderate acne and seven patients had severe acne (Table 2).

At 1-month follow-up after the last or fifth treatment, all patients showed improvements, with 37.5% (n = 15 of 40) improving to mild acne and 62.5% (n = 25 of 40) improving to clear or almost clear ($P = 0.0478$, Table 2). ILC was also reduced in all patients (n = 40) (Table 3). At 1-month follow-up, 72.5% (n = 29 of 40) of patients had greater than 75% reduction in ILC, 7.5% (n = 3 of 40) had 51%–75% reduction, 17.5% (n = 7/40) had 26%–50% reduction, and 2.5% (n = 1 of 40) had less than 25% reduction. No patient had an increase in ILC or saw no change in ILC. Of the 15 patients with a further 3-month follow-up, all had improvements to acne with 33.3% (n = 5 of 15)] improving to mild acne and 66.6% (n = 10 of 15) to clear or almost clear (Table 3), as well as a greater than 50% reduction in ILC, with 73.3% (n = 11) having greater than 75% reduction and the remaining 26.7% (n = 4) having 51%–75% reduction.

Acne-associated erythema and pigmentation were improved by laser treatment. Twenty-nine patients developed acne-associated erythema that improved at the end of the study, with 65.5% (n = 19) having greater than 75% improvement, 13.8% (n = 4) having 51%–75% improvement and 20.7% (n = 6) having 26%–50% improvement (Table 4 and Fig. 1). Seventeen patients had acne-associated hyperpigmentation (Table 4 and Fig. 2) at baseline and all

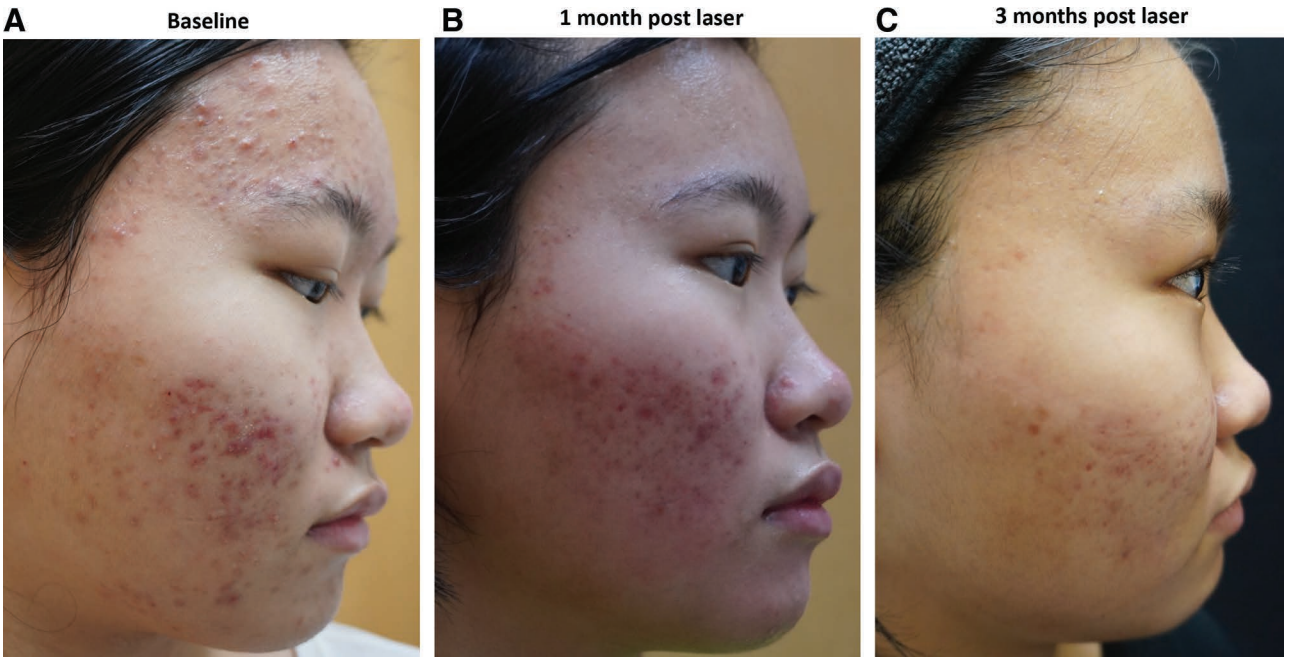

Fig. 1. Improvement in acne-associated erythema (N = 29). Patient shown at baseline (A), 1 month post-laser (B) and at 3 months post-laser (C).

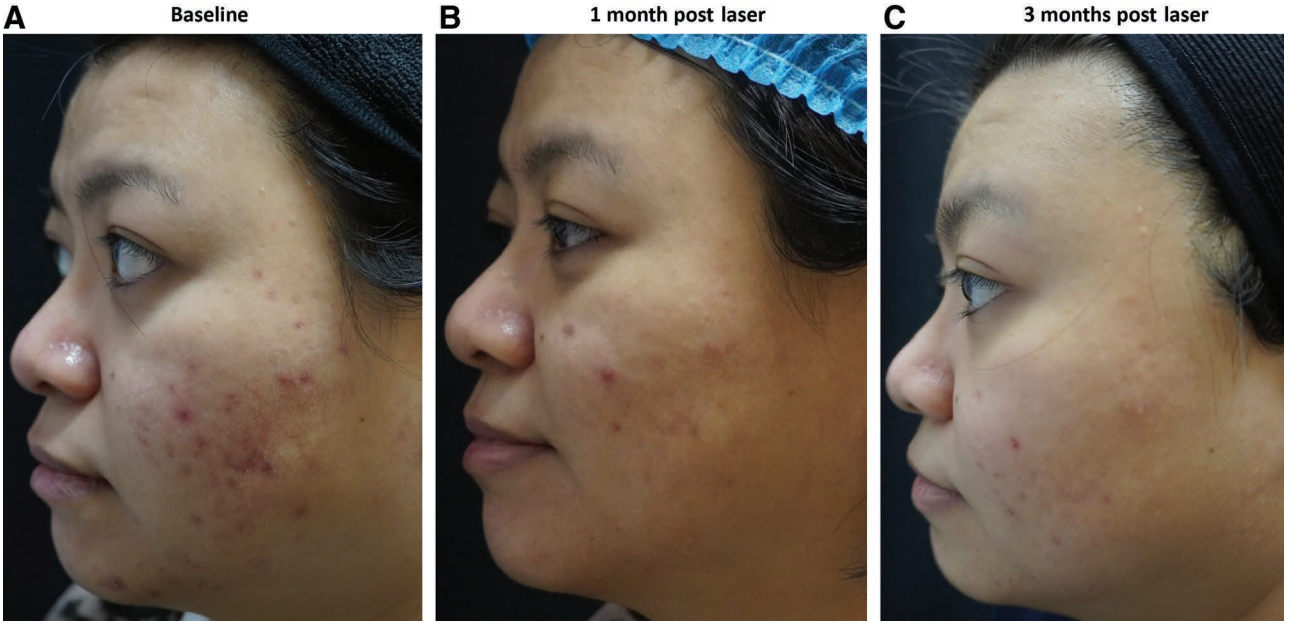

Fig. 2. Improvement in acne-associated pigmentation (N = 17). Patient shown at baseline (A), 1 month post-laser (B), and at 3 months post-laser (C).

experienced lightening of the pigmentation at 1-month follow-up: 52.9% (n = 9) had greater than 75% lightening, 5.9% (n = 1) had 51%–75% lightening, 32.3% (n = 6) had 26%–50% lightening and 5.9% (n = 1) had less than 25% lightening. The laser treatments were well-tolerated with 92.5% having a pain score of 2–4 on a 10-point visual analogue scale (mean: 3.68; Table 2). Thirty-four subjects experienced a one-to-three-point decline in seborrhea levels (on a 10-point scale; Figure 3) while six subjects experienced no changes in seborrhea.

GAIS improvements occurred in all patients with 47.5% (n = 19) scoring very much improved, 47.5% (n = 19) scoring much improved, and 5% (n = 2) scoring improved (Fig. 4). Most patients (95%; n = 38 of 40) subjects were either satisfied (40% or n = 16 of 40) or very satisfied (55% or n = 22 of 40) with the treatment, while

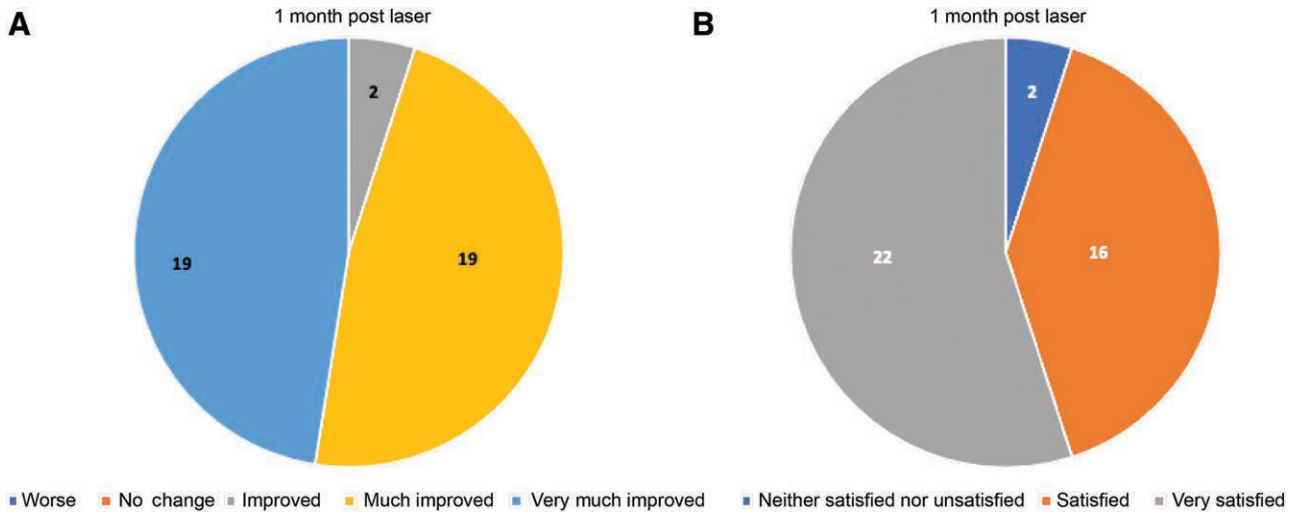

Fig. 3. Improvement in perceived seborrhea on a 10-point Scale. No improvement was seen in six patients, reductions occurred in 34 patients, 18 patients had a one-point drop, 13 patients had a two-point drop, and three patients had a three-point drop. At 1-month post-laser, improvements in seborrhea were evaluated (A) along with patient satisfaction (B) with their results.

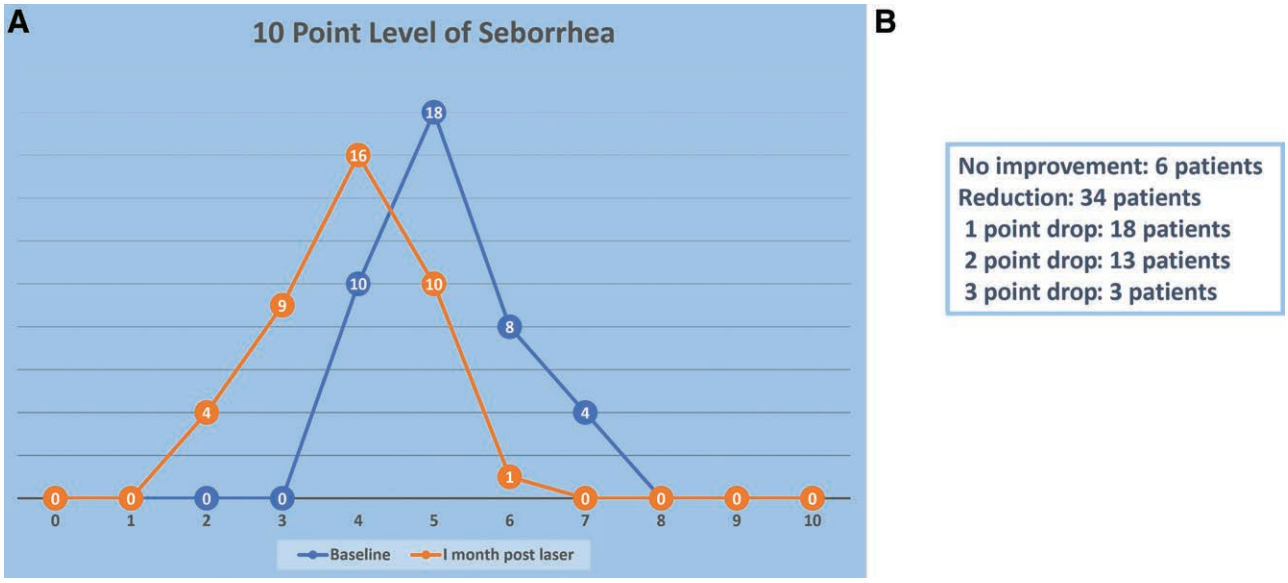

Fig. 4. One-month posttreatment ratings. A, One-month post-laser improvements as rated using the patient GAIS. B, One-month post-laser treatment satisfaction.

5% (n = 2 of 40) were neither satisfied nor unsatisfied. No patient was dissatisfied with their laser treatment.

DISCUSSION

Using a single laser with dual-wavelengths, 589-nm and 1319-nm, we showed that acne improved in all patients (n = 40) at 1-month after five laser treatments. Moderate-to-severe acne improved to mild acne in 37.5% (n = 15) of patients, and was almost clear in 62.5% (n = 25) of patients, while 72.5% (n = 29) of patients showed greater than 75% reduction in ILC. Moreover, a subgroup of 15 patients with additional follow-up at 3 months had a further greater than 50% reduction in ILC, showing continued improvements in acne severity beyond the laser treatments. Within this subgroup, acne had also improved to mild in 33.3% (5 of 15) of patients, or clear or almost clear in 66.6% (10 of 15) of patients. Laser treatments also improved acne-associated erythema and pigmentation in all affected patients and reduced the perceived seborrhea in 85% (n = 34) of patients. Overall, all patients rated improvements in their acne severity and were either satisfied or very satisfied. Treatments were also very tolerable with low pain scores, and no patient required topical anesthesia.

Laser-based treatments for inflammatory acne, such as pulsed dye lasers (PDL) and infrared lasers (1320-, 1450-, and 1540-nm), offer an alternative to the adverse events, therapeutic resistance and inconsistent outcomes

associated with conventional treatments. Inflammatory acne is often treated using a combination of two lasers, typically a PDL and an infrared laser, to target inflammation, the microvasculature, sebaceous glands and dermis.[15–18] Lasers with different wavelengths and targeting different chromophores have demonstrated efficacy in improving acne[30–32] and acne-associated conditions such as erythema,[15] hyperpigmentation[33] and scarring.[34,35]

The dual-wavelength diode laser offers multiple treatment benefits as it targets the pathogenetic factors seen in acne, such as inflammation, the microvasculature, bacteria and sebaceous glands, while also reducing acne-associated erythema, pigmentation and textural dermal changes. Only one other study using a similar laser for acne has been published—a randomized, prospective, split-face, single-blinded study on nine patients.[33] More than half of the patients in this study had reduced acne lesion counts after just one treatment with the 589-nm and 1319-nm lasers applied at 2 to 3-week intervals, and 85.7% of patients with Fitzpatrick skin type IV showed improvements that persisted even at 5.4 weeks after four treatments. The treated group demonstrated a 23.1% reduction in inflammatory acne lesions compared with an 11.1% reduction in the control group. Some investigators have found that when used as part of a laser combination, a 589-nm laser was most likely responsible for improving facial erythema,[21,32] while others saw no difference in efficacy against acne vulgaris with either a 585/1064-nm laser combination or PDL only.[17] Thus, further studies are needed to understand the efficacy of combination lasers in acne treatments. Our results also suggest that sebaceous glands can be targeted by a dual-wavelength diode lasers comprised of a 1450-nm laser, as patients indicated that they perceived the 1319-nm light to improve seborrhea. In addition to treating inflammatory acne, the 1319-nm laser component of the dual-wavelength diode laser also targets the dermis to stimulate neocollagenesis, which facilitates acne scar prevention or improvement,[35] and is useful for patients with acne who are prone to scarring.

Various studies have been published on the use of 585-nm and 595-nm PDL, as well as infrared 1320-nm or 1450-nm lasers for the treatment of inflammatory and noninflammatory acne. These lasers are used either alone or in combination. The PDL inhibits keratinocyte proliferation and inflammation while stimulating neocollagenesis,[36] thus making PDL an effective way to improve inflammatory conditions[37] like acne and acne scarring.[36,38,39]A single 585-nm PDL treatment reduced acne lesion counts by 53% at 12 weeks compared with controls,[40] while 595-nm PDL at high and low fluences reduced lesion counts at 21 days.[41] Yet, outcomes for PDL in facial acne trials are inconsistent due to the use of different protocols, devices, or combinations of modalities. One trial[42] found a 53% reduction in average acne lesion counts and a 49% reduction in inflammatory lesions versus controls (9% and 10%, respectively) at 12 weeks, while a split-face study found visible and therapeutic improvements at 6 weeks in 50% of the participants. However, facial acne did not improve significantly at 12 weeks after nonpurpuric PDL,[43] and outcomes can vary when combining PDL with other modalities such as topical treatments,[44] 5-aminolevulinic acid[45] or methylaminolevulinic acid,[46] or even with multiple PDL treatments.[47] Nonablative infrared lasers[12] have also been routinely used in acne treatments. Three treatments with a 1320-nm Nd:YAG laser transiently but significantly reduced open comedones by 27% versus controls (12%) but sebum levels, closed comedones, pustules, and papules were unaffected.[27] In patients with moderate-to-severe acne, fractional 1320-nm Nd:YAG lasers reduced inflammatory lesions by 57%, noninflammatory lesions by 35% and sebum production by 30%.[48] In patients with inflammatory facial acne, 1450-nm diode lasers used at 4- and 6-week intervals[49] reduced acne lesions by up to 83% after three treatments. Moreover, significant, long-term acne remission was possible when using a 1450-nm diode laser[50] at 14 or 16J per cm^2 fluences, as the average lesion counts decreased by up to 76.1% at 12 months. Acne scarring and sebum production also improved, suggesting that the 1450-nm diode laser reduced sebaceous gland activity. However, a randomized split-face study found no reduction in inflammatory lesions or acne grades with 1450-nm lasers.[51] Clearly, laser-based combinations are safe and effective for inflammatory facial acne, acne scars, and postinflammatory erythema, but more data are needed.

Unlike PDL, the dual-wavelength laser does not require consumables, which lowers its overall running costs. Using a single device to treat the different pathogenic factors in inflammatory acne also reduces treatment costs. In addition, this dual-wavelength laser improved acne-associated conditions like erythema and pigmentation, improvements which do not occur with other infrared lasers used for inflammatory acne. In Asians, acne-associated erythema and pigmentation are common and can cause more distress than the acne lesions themselves. The dual-wavelength diode laser is, thus, beneficial, as it treats acne, erythema and pigmentation simultaneously.

This study was limited by its small sample size and ethnic distribution and would benefit from the inclusion of larger cohort sizes and Fitzpatrick skin type diversity. In addition, given the efficacy of combination treatments, other modalities and measurement scales or metrics (eg, Leeds scales) should be explored to allow comparison with other studies and generalization of the results. Notably, efforts to determine which treatment led to improvements may be complicated by the simultaneous initiation of retinoid and dual-wavelength laser treatments in retinoid-naive (and treatment-naive) patients. However, treatments were conducted in this manner, as retinoid is used as a standard treatment, our patients often refuse laser-only treatments, and we wanted to ascertain the effectiveness of dual-laser therapy in addition to retinoid therapy. Thus, a future split-face study in which retinoid therapy-treated patients then received dual-laser or placebo treatments to contralateral face sides, could provide more insights. Moreover, a judgement of the effectiveness of laser treatments at reducing acne erythema, pigmentation and lesions could be confounded by patient-related factors, including nightly use of topical retinoids, better hygiene and skin care, less acne manipulation, reduced consumption of spicy foods, avoiding UV exposure, and

the use of silicone-free skin or hair washes. Finally, patients in our study were not provided with other acne-improving interventions, such as skin care, and may have used these of their own accord. All of these factors will need to be accounted for in subsequent studies.

CONCLUSIONS

Acne is a common disorder in Asians and is typically treated with hormonal or antibacterial topical agents, and isotretinoin. Low-fluence lasers have a proven efficacy in improving acne with minimal complications or adverse events. This study shows that dual-wavelength lasers are highly effective in Asians with Fitzpatrick skin type III-V affected by moderate-to-severe inflammatory acne, and beneficial for those with acne-associated erythema or pigmentation, or who are prone to acne scars. Given its high safety and tolerability, it is also ideal for patients who have refused or are contraindicated to oral acne medications, those who are noncompliant with topical treatments, or those who develop acne treatment side effects. Thus, the dual-wavelength laser offers patients a safe, effective, and satisfying treatment for acne.

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DISCLOSURES

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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