Efficacy and Safety of Ablative Resurfacing With A High-Energy 1,064 Nd-YAG Picosecond-domain Laser for the Treatment of Facial Acne Scars in Asians

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INTRODUCTION

Acne vulgaris is a common skin disease that can lead to permanent scarring [1-3]. Acne scarring significantly impairs patients’ quality of life and has been described as a risk factor for depression, suicide, low academic performance, and unemployment [4,5]. The management of acne scarring depends on the types of acne scars and the limitations of the treatment modalities [6]. Current treatment modalities include chemical peeling, dermabrasion, needling, filler, platelet-rich plasma, ablative lasers, fractional/nonablative lasers, and punch excision [7-14]. Despite the availability of multiple treatment modalities, management of acne scars remains challenging. The 755 nm Alexandrite picosecond laser with a diffractive lens array has demonstrated clinical efficacy for improving facial acne scars [15,16]. However, the use of a high-energy 1,064 nm Nd:YAG picosecond-domain laser for ablation and resurfacing of acne scars have never been investigated. In this study, we examined the efficacy and safety of a new 1,064 nm picosecond-domain fractionated laser with a high-energy setting for the treatment of acne scars in Asians.

METHODS

Patients aged 18–50 years with Fitzpatrick skin type III–V and facial acne scars were enrolled. The Fitzpatrick skin type was determined by the study investigators based on a sun-exposure reaction questionnaire and the investigator’s objective evaluation. To be included, subjects were required to have facial acne scars and be otherwise healthy without pregnancy, lactation, a history of skin cancer, keloidal scarring, active infection, immunodeficiency disorders, and light hypersensitivity or taking phototoxic medications. Patients who received resurfacing procedures such as laser treatment or chemical peels to the face within the previous 6 months were excluded.

Subjects were treated with a 1,064 nm picosecond laser (8 mm spot, 0.7–1.0 J/cm², 5 Hz) every 4 weeks for three sessions. Two blinded dermatologists evaluated the pre- and 3-month post-treatment images with a 10-point improvement scale. Subject pain, global improvement, and satisfaction were also assessed. The Facial Acne Scar Quality of Life (FASQoL) questionnaire was used to evaluate the subjects’ quality of life.


Key words: acne scars; treatment; fractionated; picosecond; laser

OBJECTIVES: There have been few studies regarding the use of a picosecond-domain laser for acne scars in Asians. This prospective study evaluated the efficacy and safety of a high-energy 1,064 nm Nd:YAG picosecond-domain laser for ablation and resurfacing of facial acne scars in Asians.

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months were excluded as well. This study was approved by the institutional review board of the Taipei Veterans General Hospital (2018-02-004A) and informed consent was obtained from all the subjects.

**Laser Treatment**

A picosecond-domain, 1,064/532 nm Nd:YAG laser (Discovery PICO®; Quanta system S.p.A., Samarate, Italy) was used for all laser treatments. The device is equipped with a specialized handpiece with micro-lens array (MLA), which fractionates the laser beam into 66 microbeams in an 8 mm circular diameter (Fig. 1a). The laser system delivers an adjustable energy level, from 0.05 to 1.4 J/cm². The calculated energy level ranges from 0.45 to 12.7 mJ per microbeam. With a low scattering rate, the MLA is able to deliver 90% of the set energy in the high fluence regions, which cover 5% of the treatment spot in total. Before treatment, each acne scar within the treatment area was mapped and photographed. Topical anesthetic cream (EMLA®; AstraZeneca, Wilmington, DE) was applied with occlusion for 40 minutes. With a fixed spot size of 8 mm, fluence of 0.7–1.0 J/cm², repetitive rate of 5 Hz, and two passes, a 1,064 nm picosecond laser with MLA was applied to all areas of facial acne scars, including rolling, boxcar, and icepick scars. Double laser passes were administered sequentially in rows, approximatively corresponding to 10% surface of the treatment area. A total of 1,200–1,600 pulses were given per session based on experience with the laser and tissue reaction. Immediate erythema and mild oozing of bloody serous

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**Fig. 1.** (a) The 66-microbeam pattern of the 1,064 nm Nd:YAG picosecond-domain laser with micro-lens arrays. (b) There was no significant correlation between subject age and dermatologist-rated improvement score (Spearman rank $\rho = -0.298$, $P = 0.202$). (c) There was no statistically significant difference in the dermatologist-rated improvement score between men and women (median [range]: 3.0 [−6 to 8] in men vs. 4.0 [−7 to 8] in women, $P = 0.641$). Lines indicate median values. (d) Histology showing epidermal ablation (H&E stain, ×40). (e) High-power view (H&E stain, ×100). (f) A well-defined, intra-epidermal vacuole (H&E stain, ×40). (g) High-power view (H&E stain, ×100). H&E, hematoxylin and eosin.
Evaluation of Efficacy

Two-dimensional photographs (Nikon D640) were taken before the initial laser treatment and 3 months after the final treatment session. The photographs were taken in standardized lighting and photography sitting areas. To avoid confirmation bias, two blinded dermatologists evaluated the photographs in pairs of pre- and 3-month post-treatment randomized to left and right panels. For each subject, improvement in volume, texture, and overall appearance of the treatment areas was assessed with before-and-after photographs. The reviewers were asked to identify which image was the pre-treatment photograph and then rate the degree of improvement using a 10-point global aesthetic improvement scale (1 = 10%, 2 = 20%, 3 = 30% improvement to 10 = total clearance). In cases where the reviewer incorrectly identified a pre-treatment photograph, the subject’s evaluation obtained a negative score.

At 1 and 3 months after the final treatment, subjects were asked to evaluate the improvement in overall appearance on a 10-point scale (1 = 10%, 2 = 20%, 3 = 30% improvement to 10 = complete clearance). Subjects also rated their satisfaction with improvement in overall appearance and texture on a 5-point Likert scale (−2 = very dissatisfied, −1 = dissatisfied, 0 = no opinion, 1 = satisfied, and 2 = very satisfied) at 1 and 3 months after the final treatment. To assess the impact of treatment on quality of life, subjects were asked to complete the Facial Acne Scar Quality of Life (FASQoL) questionnaire before the initial treatment and 3 months after the final treatment. FASQoL is a 10-item instrument with three domains assessing the impact of scars on emotions, social functioning, and work/school on a 5-point rating scales with a recall period of the past 7 days (0 = not at all, 1 = a little, 2 = somewhat, 3 = very much, and 4 = extremely) [17].

Evaluation of Safety

Subjects assessed their discomfort after each treatment session using the Wong-Baker Faces Pain Rating Scale (0 = no discomfort; 10 = intolerable pain). Subjects were also required to record post-treatment effect including erythema, edema, exfoliation, petechiae, and blistering. At 3 months after the final treatment, two blinded dermatologists independently evaluated hypopigmentation, hyperpigmentation, and scarring.

In Vivo Study

An in vivo study was conducted in one male subject prior to the surgical excision of a deep box scar, which did not greatly benefit from the laser treatment. The patient received the laser treatment 30 minutes prior to the punch excision.

Statistical Analysis

Descriptive statistics were applied to summarize the data. Comparing different groups was performed using the Wilcoxon rank-sum test and the Kruskal–Wallis test. The Spearman rank correlation coefficient was calculated on age, improvement score, and satisfaction score. A two-sided P < 0.05 was considered to be statistically significant. Data analyses were performed with the software SPSS version 22.0 (IBM, Armonk, NY).

RESULTS

Overall, 20 subjects (13 males and 7 females, ages 21–39 years, median age 28 years) with Fitzpatrick skin types III–V were enrolled, and all of them completed the study. Most subjects have a mix of several types of scars and were categorized into three types: rolling-predominant, boxcar-predominant, or icepick-predominant scars (Table 1).

Efficacy Evaluated by Dermatologists

Of the 40 image sets (20 subjects evaluated by two dermatologists), blinded reviewers correctly identified 33 (82.5%) baseline images (Table 2). The reviewers rated a median improvement score of 3 (range −7 to 8) for all subjects. After averaging scores from the two reviewers, 17 of 20 (85%) subjects showed some level of improvement and 9 (45%) subjects had an improvement score of at least 3 (≥30%). For the 15 subjects whose baseline image was correctly identified by both reviewers, the median improvement score was 4.5 (range 3–8). Subjects with rolling-predominant scars responded better than subjects with boxcar-predominant and icepick-predominant scars, with a median (mean [range]) improvement score of 4.5 (4.08 [−2 to 8]), 4 (2.39 [−7 to 8]), and 2 (0.1 [−6 to 3]) for rolling-predominant, boxcar-predominant, and icepick-predominant groups, respectively (Fig. 2). The dermatologist-rated improvement scores were not significantly associated with age, sex, or type of skin (Fig. 1b–c).

Efficacy Evaluated by Subjects

The subject rated median improvement score was 6.5 at 1 month after the final treatment session. Further improvement was reported at 3 months with a median score of 8 on global aesthetic improvement (P = 0.004). Subjects reported high satisfaction rates with the treatment results. Overall, 55% and 25% of subjects were satisfied and very satisfied with their results at the 1-month follow-up, respectively. Subjects maintained satisfaction at the 3-month follow-up, with 55% and 40% being satisfied and very satisfied with the treatment outcome, respectively. There was a statistically significant correlation between subject-rated improvement score and satisfaction score (Spearman’s rank ρ = 0.653, P = 0.002). FASQoL questionnaires showed significant improvement in the quality of life after laser treatment (median [range]: 21 [4–40] before treatment vs. 10 [0–24] after treatment, P < 0.001).
Immediate post-treatment histology revealed epidermal ablation and well defined, intra-epidermal vacuoles (Fig. 1d–g). Degenerating necrotic keratinocytes were seen around the vacuoles.

**DISCUSSION**

This prospective study demonstrates that the high-energy 1,064 nm picosecond laser with MLA is a safe and effective treatment modality for acne scars in Asians. As evaluated by two blinded dermatologists, the improvement was observed in 85% of the patients with a median improvement score of 3 after three treatment sessions. Subjects’ satisfaction was high with 19 of 20 subjects being satisfied or very satisfied with their aesthetic results. A significant improvement in subjects’ quality of life was also observed. There was no dyspigmentation, prolonged erythema, edema, acneiform eruption, milia formation, hypertrophic scar, and delayed wound healing after the treatment.

With the MLA, the high energy fluence delivers energy to only 5% of the treated area in a single pass. Theoretically, the efficacy can be enhanced by increasing the passes or treatment sessions. In our study, 1,200–1,600 laser pulses seemed inadequate for a full-face treatment compared with other studies using different picosecond laser devices [18,19]. In the study by Haimovic et al., who used a 755 nm Alexandrite picosecond laser (PicoSure®; Cynosure Inc., Westford, MA), 3,000–7,000 pulses were delivered in 2–4 passes for the whole face in 56 patients with darker skin types [16]. However, regarding the larger spot size of 8 mm round and the higher fluence of 0.7–1.0 J/cm² of the device we used, the smaller number of laser pulses in our study was reasonable. Besides this, perhaps due to the larger numbers of laser pulses given in the Haimovic et al. study, six subjects developed post-inflammatory hyperpigmentation (PIH), which was not observed in our study. Dierickx suggested that increased treatment pulses did not offer additional benefits for acne scars [18]. In contrast, Huang et al. showed that session number is positively associated with clinical improvement [19]. Therefore, further studies are needed to determine the appropriate laser pulses and treatment sessions in the treatment of acne scars.

While grading scales exist for acne scarring, no consensus has been reached on the scar assessment tool to be selected for a given condition [20]. Therefore, it is difficult to compare the results of different studies. The efficacy of laser treatment was assessed based on a 10-point improvement scale in our study, while a 4-point scale or a 5-point scale was used in other studies [15,19]. Compared with our study’s median improvement score of 3 on a 10-point scale, the study by Bernstein et al. demonstrated a mean improvement score of 1.4 (range 4–6; 95% CI: 0.85–1.9) at 3 months after 4 monthly treatments with a 1,064 and 532 nm picosecond-domain laser (PicoWay®, Syneron-Candela Inc., Wayland, MA). The system...
used in the Bernstein et al. [21] study also utilized a fractionated handpiece, which delivered an energy level of 1.3 to 2.9 mJ per microbeam. The energy level used in our study is at least three times higher, and the treatment outcome is better without PIH being observed.

Previous studies of fractional picosecond-domain devices demonstrated the dermal remodeling effect of the LIOB induced by the laser [22,23]. Our study revealed the optical breakdown and epidermal ablation produced by the 1,064 nm picosecond-domain laser. To the best of our knowledge, there is only one study reporting microscopic ablation of the epidermis after irradiation [24]. This is most likely due to the fluence used for treatment. The energy per microbeam used in our study was 5.3–9.1 J per microbeam, while others were 1.3–2.9 J per microbeam [21]. Using the fractional picosecond Alexandrite laser, Brauer et al. [15] showed that the intra-epidermal vacuoles were associated with increased dermal collagen, elastic tissue, and mucin. In the study by Guida et al. [25], who used the same 1,064 nm picosecond laser as ours, reflectance confocal microscopy revealed reticulated collagen fibers arranged in a net, suggesting increased collagen remodeling after laser treatment. However, further studies are necessary to elucidate the mechanisms underlying the clinical improvement in acne scars from the treatment.

Asians have high melanocytic activity; therefore, they have a substantial risk of PIH after ablative lasers, such as erbium:yttrium–aluminum–garnet or carbon dioxide (CO2) lasers [26–29]. Although the ablative, non-fractionated CO2 laser is highly efficacious for the treatment of acne scars, it might produce prolonged dyspigmentation and longer downtime. Fractionated CO2 lasers greatly reduce the downtime but compromise the efficacy. Although fractionated, non-ablative lasers have been proved to be much safer than the CO2 laser, their efficacy in treating acne scars is suboptimal [30]. In our study, the longer downtime and increase in pain during the procedure might be associated with the epidermal ablation produced by the high fluence level. However, this 1,064 nm picosecond-domain laser achieved significant improvement in acne scars with a low PIH risk, suggesting potential advantages of this device over earlier ablative and non-ablative fractionated lasers for treating acne scars in darker skin types.

The low incidence of PIH in our study may be explained by the MLA technology of this device. The MLA handpiece delivers the laser in an array of narrow, focused high-precision microbeams to create the thermal/plasma effect on both the epidermis and dermis. When the laser is
delivered at high fluence, plasma formation occurs before photons reach the dermis [31]. The multi-photon ionization produces an electron avalanche, thereby leading to an epidermal breakdown. The surrounding tissue has limited collateral damage in the picosecond domain to ensure rapid healing and minimum side effect, explaining the low incidence of PIH [22,32].

The limitations of this study include relatively small sample size, efficacy evaluation based on two-dimensional photography, a follow-up period of only 3 months, and lack of a comparative group. The use of two-dimensional imaging would probably not capture subtle changes in acne scars. Thus, this might explain the discrepancy between the assessment of dermatologists and subjects’ self-assessment. Because scar tissue remodels over many months, further improvement could occur over a longer follow-up period. Finally, despite numerous tools available to assess the severity of acne scars, the lack of consensus concerning acne scar evaluation makes it difficult to compare our results with those from other studies [33].

This is the first report investigating the efficacy and safety of the versatile picosecond laser with MLA in the treatment of acne scars in Asians. In conclusion, the 1,064 nm picosecond-domain laser with a high-energy setting is a safe and effective treatment modality for facial acne scars in Asians. The positive clinical outcomes and the safety profile suggest that the 1,064 nm picosecond-domain laser is a promising therapeutic option for facial acne scars.

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References