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CLINICAL REPORT

Treatment of abdominal striae distensae in Fitzpatrick skin types IV to V using a 1064-nm picosecond laser with a fractionated microlens array

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Abstract

Background: Striae distensae are atrophic dermal scars that can cause psychosocial distress among affected patients. Despite numerous available therapeutic modalities, no gold standard treatment has been established.

Objective: To evaluate the long-term efficacy and safety of a fractional 1064-nm picosecond laser for the treatment of striae alba in individuals with dark skin types.

Materials and Methods: Twenty volunteers with Fitzpatrick skin types IV–V who presented with striae alba were enrolled. Subjects were treated with a fractional 1064-nm picosecond laser for four sessions at 4-week intervals. The skin texture, average melanin index (MI), and melanin variation score were assessed using Antera 3D® before treatment, at 1 month after the second treatment, and at 1, 3, and 6 months after the last treatment. Two independent investigators evaluated clinical improvement by comparing pretreatment and posttreatment photographs. The patient satisfaction rates were likewise assessed. Adverse effects were recorded during the entire study period.

Results: Significant improvement of skin texture was seen at 1 month after the final treatment ($p < 0.001$) and continuously improved until the 6-month follow-up visit ($p = 0.003$). The average MI significantly increased at 1 month after the final treatment ($p < 0.001$), whereas the melanin variation score decreased throughout the follow-up period. Investigator assessment at the 6-month follow-up revealed that 90% of subjects had moderate to marked improvement of striae appearance. Only two of 20 subjects (10%) developed transient postinflammatory hyperpigmentation (PIH) after laser treatment.

Conclusion: Fractional picosecond 1064-nm laser is effective and well-tolerated for the treatment of striae alba in dark-skinned individuals with a low incidence of PIH.

KEYWORDS

1064 nm, dark-skinned type, Fitzpatrick skin type IV, Fitzpatrick skin type V, fractional picosecond laser, microlens array, stretch marks, striae alba, striae distensae

1 | INTRODUCTION

Striae distensae (SD) or stretch marks are dermal scars affecting patients of all genders and races. SD are common dermatologic lesions that often arise as a result of rapid weight change, certain endocrine conditions, or prolonged exposure to steroids.[1,2] They are primarily considered an aesthetic concern, however, they can cause considerable psychological distress in affected individuals. SD lesions initially present as raised, edematous, pinkish to erythematous linear plaques (striae rubra). Over time, they become white and atrophic (striae alba) owing to local collagen breakdown and reorganization of collagen and elastin bundles.[1,3–5]

SD or stretch marks result from dermal scarring and epidermal atrophy. The epidermis is thin with loss of dermal papillae and rete ridges, while the dermis shows a decrease in extracellular matrix components, particularly collagen, fibronectin, fibrillin, and elastin.[6,7] With the development of SD, the collagen bundles separate, and collagen fibrils fail to form bundles. The elastic network is severely disrupted as tropoelastin (soluble elastin)-rich fibrils are unable to organize into their normal form.[8]

Due to the prevalence and permanence of SD, there is substantial demand for reliable treatment options; however, no method of prevention or treatment has shown consistent results.[2] Although various treatment modalities including laser and light therapies, chemical peel treatments, collagen injections, radiofrequency (RF) devices, microneedling, and microdermabrasion have been attempted for SD, there is currently no gold standard or consistently effective therapy for this condition.[9] The majority of treatments aim to increase collagen production, reduce erythema, and improve pigmentation.

Picosecond-domain lasers are a recent innovation for tattoo removal in the realm of laser technologies. They generate ultrashort pulse durations in the picosecond range, thereby allowing more photoacoustic effects and less nonspecific photothermal damage.[10] In recent years, fractional picosecond lasers have been increasingly utilized for the treatment of dyspigmentation, acne scars, and skin rejuvenation.[11–15] By attaching a modified lens to the handpiece, the laser beam is fractionated into multiple focused areas of higher-intensity laser energy. Within these localized zones, an electron avalanche breakdown alternatively termed "laser-induced optical breakdown" (LIOB) produces focal vacuoles in the epidermis in a nonthermal manner. This closed, nonthermal injury is associated with increased production of dermal collagen, elastic tissue, and mucin with minimal posttreatment downtime and has been demonstrated to improve atrophic acne scars[14,16,17] and photodamaged skin.[18,19]

Fractional picosecond lasers have shown promising results for the treatment of striae alba in subjects with Fitzpatrick skin type (FST) II–III without any adverse effects.[20,21] In this study, the authors prospectively evaluate the long-term safety and efficacy of a fractional 1064-nm picosecond laser for the treatment of striae alba in Asians with FSTs IV–V.

2 | MATERIALS AND METHODS

2.1 | Study design

This was a single-center prospective, self-controlled study, which was approved by the Siriraj Institutional Review Board of Mahidol University, Bangkok, Thailand. All subjects provided informed consent before enrollment. This clinical study was registered at www.clinicaltrials.gov with identification code NCT04456257.

2.2 | Participant selection

Twenty healthy female subjects aged 18–60 years old with FSTs IV–V who had abdominal striae alba for more than 3 months were enrolled. Subjects were excluded if they had a history of smoking, photosensitive dermatitis, hypertrophic scars or keloids, underlying connective tissue disease, isotretinoin use, active dermatitis or skin infection in the treatment area, family or past history of malignancy, were pregnant or breastfeeding, were applying topical retinoids, hydroquinone, alpha hydroxy acids or steroids within 3 months before starting the study and for the entire duration of the study period, had hyaluronic acid filler injections, underwent chemical peeling or laser treatments in the area in the past 6 months or had significant weight fluctuations in the past 6 months.

2.3 | Intervention

Demographic data, age of striae, and medical history were recorded for all participants before starting the treatment. All subjects were treated with a 1064-nm picosecond laser (Enlighten™ System; Cutera Inc.) on their abdominal striae alba. Topical anesthesia (2.5% lidocaine hydrochloride and 2.5% prilocaine) was applied and left under occlusion for 1 h before the procedure. The laser settings included the microlens array (MLA) handpiece with 8-mm spot size, fluence of 0.6 J/cm^2, 750 ps pulse width, 10 Hz repetition rate, and two passes with approximately 15%–20% of pulse overlapping (along the line of striae alba in one pass and perpendicular to the line for the other pass). The MLA beam splitter delivers an array of 180 μm diameter microbeams, containing 460 microbeams per cm^2. The resulting endpoint was mild to moderate erythema and petechiae. A total of four laser treatment sessions were performed at 4-week intervals. Patients were instructed to apply a fragrance-free and noncomedogenic moisturizing cream on the treatment area twice daily. Follow-up assessments were done at 1, 3, and 6 months after the final treatment.

2.4 | Assessment

Objective assessment for striae texture, average melanin, and melanin variation was assessed using a 3D skin imaging device (Antera® 3D CS; Miravex Limited), which offers an accurate comparison of before and after images with a ±5% error. The images were taken pretreatment, at 1 month after the second treatment and at 1, 3, and 6 months after the final treatment. Standardized digital photographs using identical camera settings, lighting, and patient positioning were obtained at every visit. Overall clinical improvement was evaluated by two independent board-certified dermatologists by comparing pretreatment and posttreatment clinical photographs using a 4-point grading scale (0 = no improvement, 1 = less than 25% [minimal], 2 = 25%–50% [moderate],

3 = 51%–75% [marked], 4 = more than 75% [excellent] improvement) at 1, 3, and 6 months after the last treatment. A self-administered questionnaire was used to assess patients' satisfaction rates at 1, 3, and 6 months after the last treatment. Pain scores were recorded immediately after each treatment using a 10-point pain scale (0 = no pain to 10 = severe pain). The subjects were instructed to observe the healing time including the duration of erythema and scabbing of the treatment area and reported them at every treatment visit. All adverse effects were recorded during the study.

2.5 | Statistical analysis

Statistical analysis was performed using SPSS version 18.0 (IBM). All categorical data were reported as a number (percentage) and the continuous variables were reported as a mean ± SD. A repeated measure analysis of variance was used to compare roughness score, average MI, and melanin variation between pretreatment and posttreatment at each timepoint. $p < 0.05$ was considered statistically significant.

3 | RESULTS

A total of 20 female subjects, mean age of 36.5 ± 6.23 years with FSTs IV (95%) and V (5%) were enrolled. The duration of SD was 9.53 ± 5.21 years. All subjects enrolled completed the treatment protocol and were followed up until the end of the study.

3.1 | Evaluation of efficacy

Significant improvement in skin texture was observed at 1 month after the final (fourth) treatment ($p < 0.001$) and at 3 months after the final treatment ($p < 0.001$). Continuous improvement of the skin texture was observed until 6 months after the final treatment ($p = 0.003$) when compared with baseline (Figures 1–3) The average MI (Figure 4) demonstrated a significant increase in the color of the striae alba at 1 month after the final treatment ($p < 0.001$) compared with baseline. However, at 6 months after treatment, the average MI declined to levels comparable to baseline without any statistically significant differences ($p = 1.000$). The melanin variation gradually decreased from baseline at 1, 3, and 6 months after treatment but likewise revealed no statistically significant differences (Figure 5).

3.2 | Physician assessment rating

Investigator assessment of overall striae improvement at 1-month follow-up indicated that 65% of the subjects had at least 25%–50% improvement of their SD. At the 3-month follow-up, 90% of the patients were rated as having 25%–50% improvement of their SD. At the 6-month

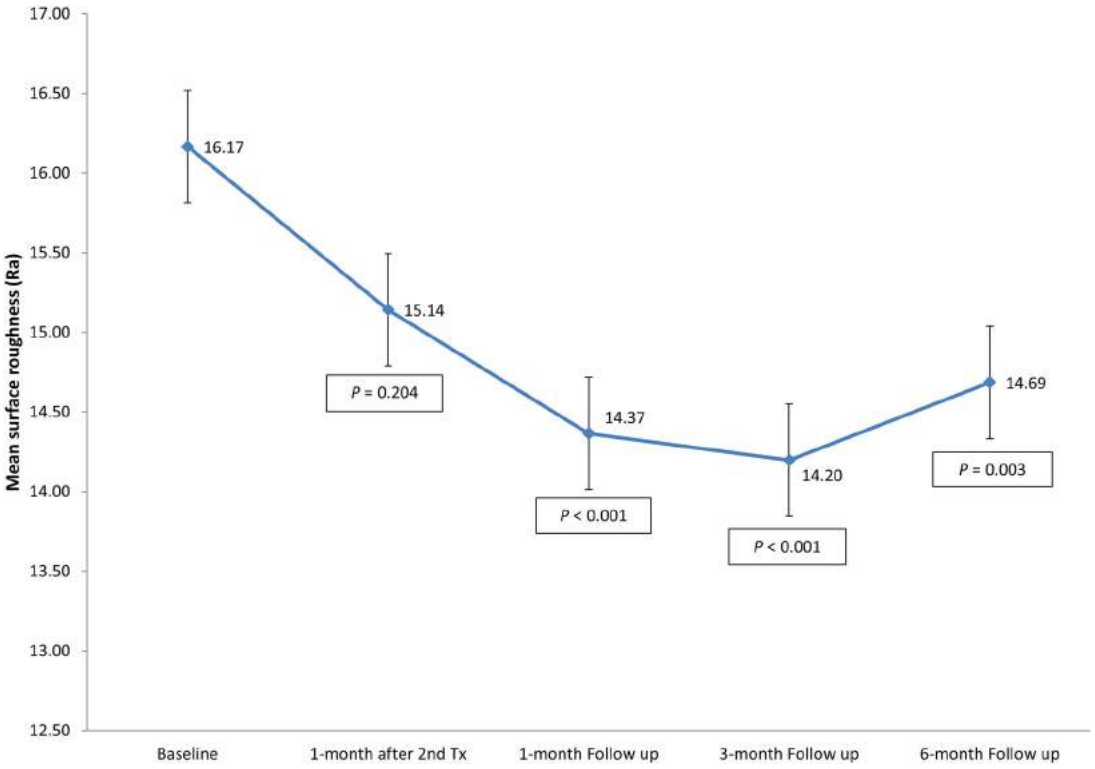

FIGURE 1 Mean of the surface roughness scores at each time point

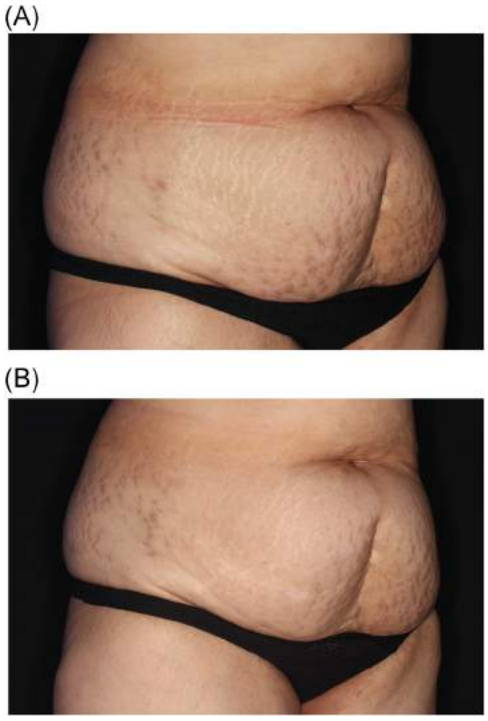

FIGURE 2 Clinical appearance of striae distensae (SD) in a 46-year-old participant with Fitzpatrick skin type IV. At baseline (A) and at 6 months after the final (fourth) treatment (B)

follow-up, 30% and 60% of the patients were rated as having 51%–75% and 25%–50% improvement of their striae, respectively. No patient was rated as having no improvement (Figure 6).

3.3 | Patient satisfaction rating

Patients' self-assessment of overall striae improvement revealed that 70% of the patients rated themselves as having at least 25%–50% improvement at the 1-month follow-up. At the 6-month follow-up, 85% of the patients rated themselves as having at 25%–50% improvement of their striae, and 5% rated themselves as having over 75% improvement. None of the patients reported any improvement of lesions (Figure 7).

3.4 | Evaluation of pain, healing time, and adverse events

The average pain scores rated by the study subjects were 3.29 ± 1.76 from 10. The average healing time was 5.67 ± 2.31 days. All patients reported erythema after laser treatment, which resolved on average within 1.96 ± 0.93 days. Nine out of 20 patients (45%)

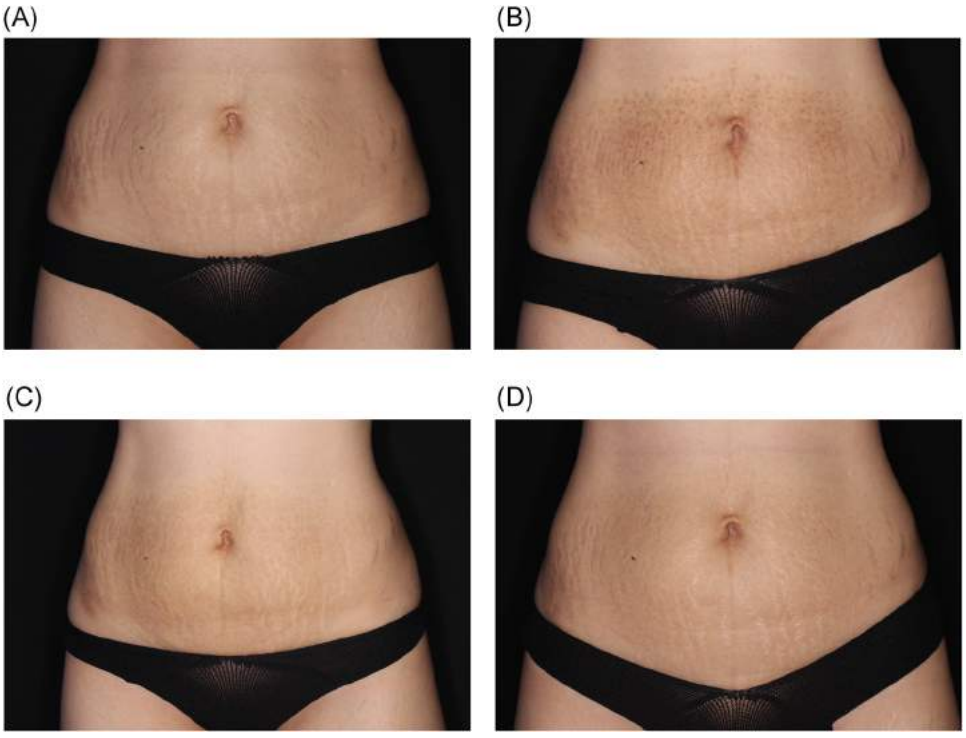

FIGURE 3 Clinical appearance of one of two participants in the study who experienced postinflammatory hyperpigmentation (PIH). At baseline (A), moderate PIH develops at 1 month after the final (fourth) treatment (B), PIH at 3 months after the final treatment (C), and improvement of the striae distensae and PIH at 6 months after the final treatment (D)

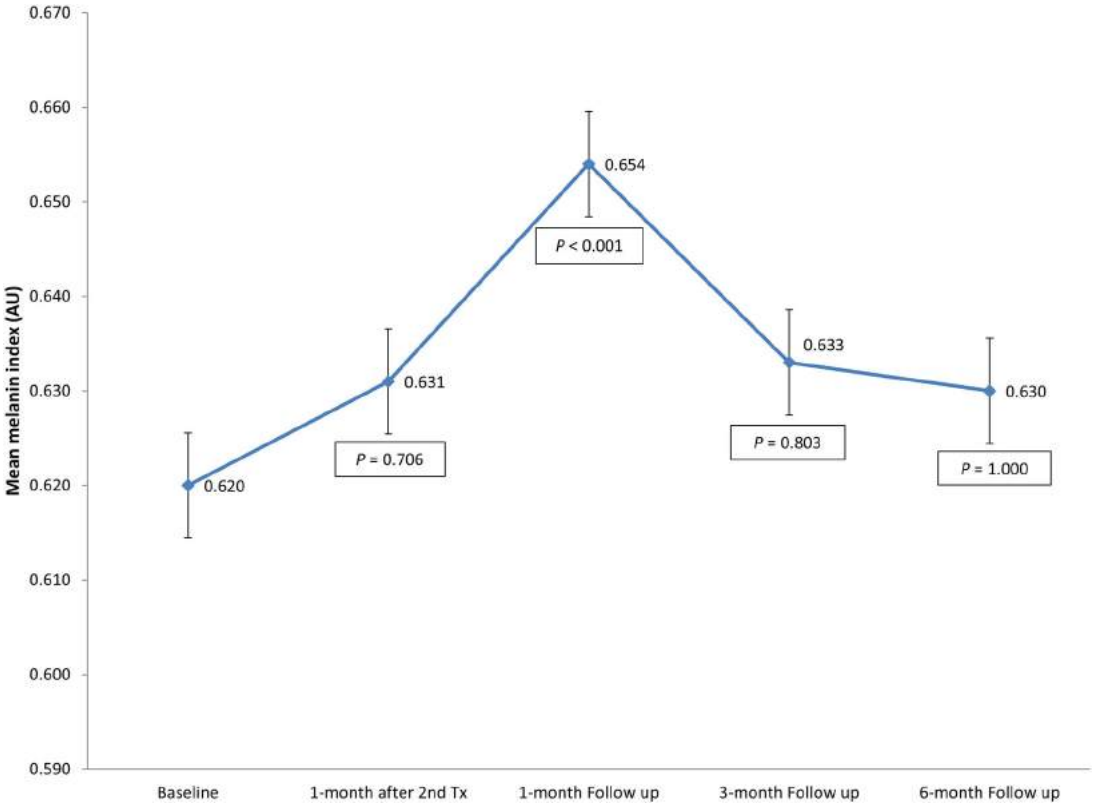

FIGURE 4 Mean of the melanin index at each time point

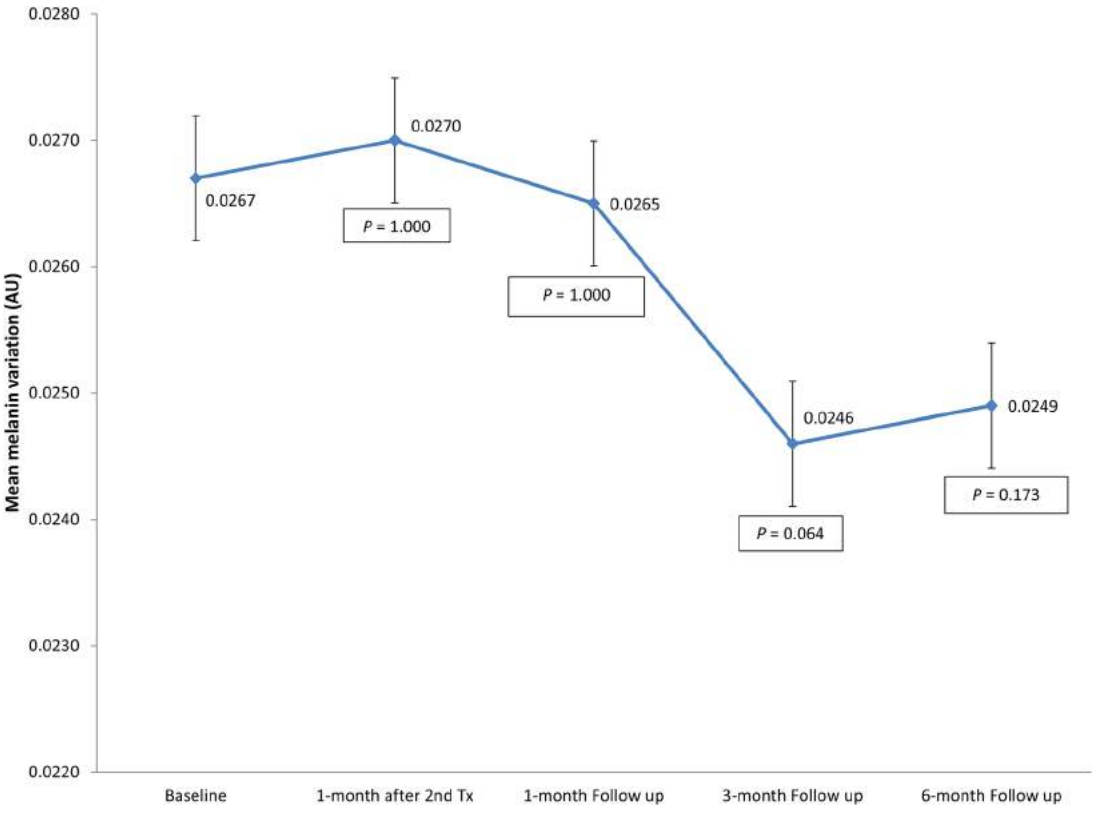

FIGURE 5 Mean of the melanin variation at each time point

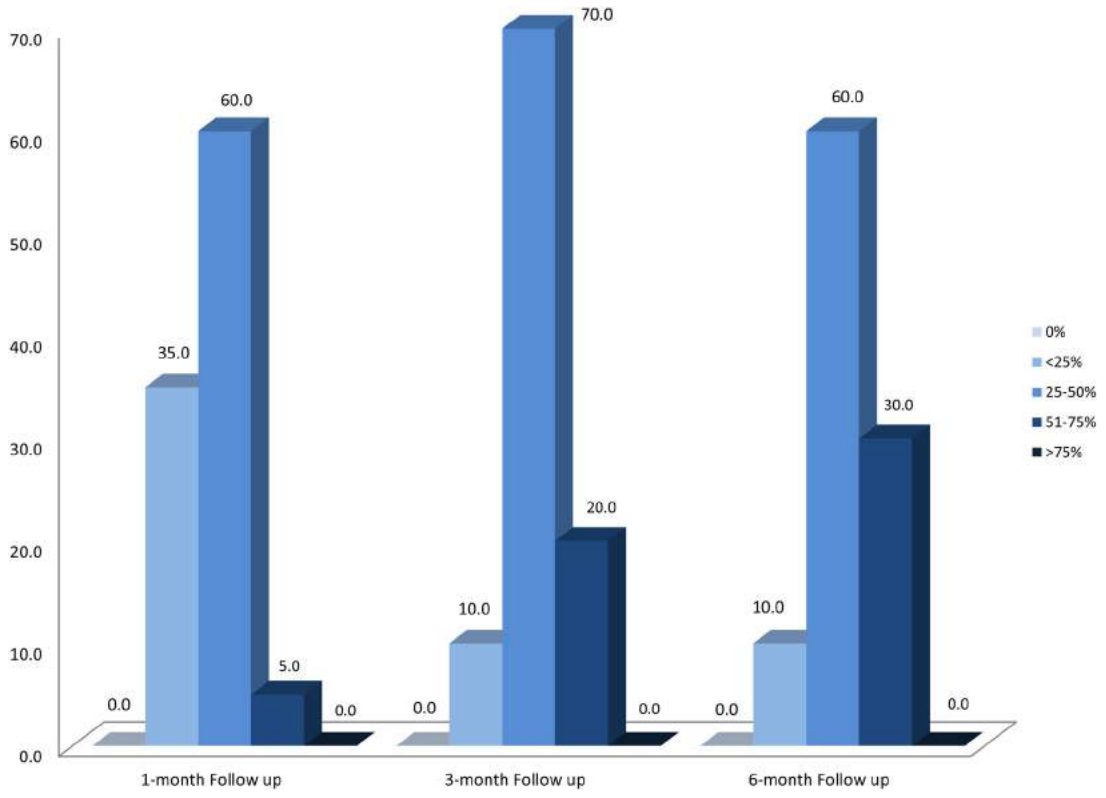

FIGURE 6 Physician assessment rating

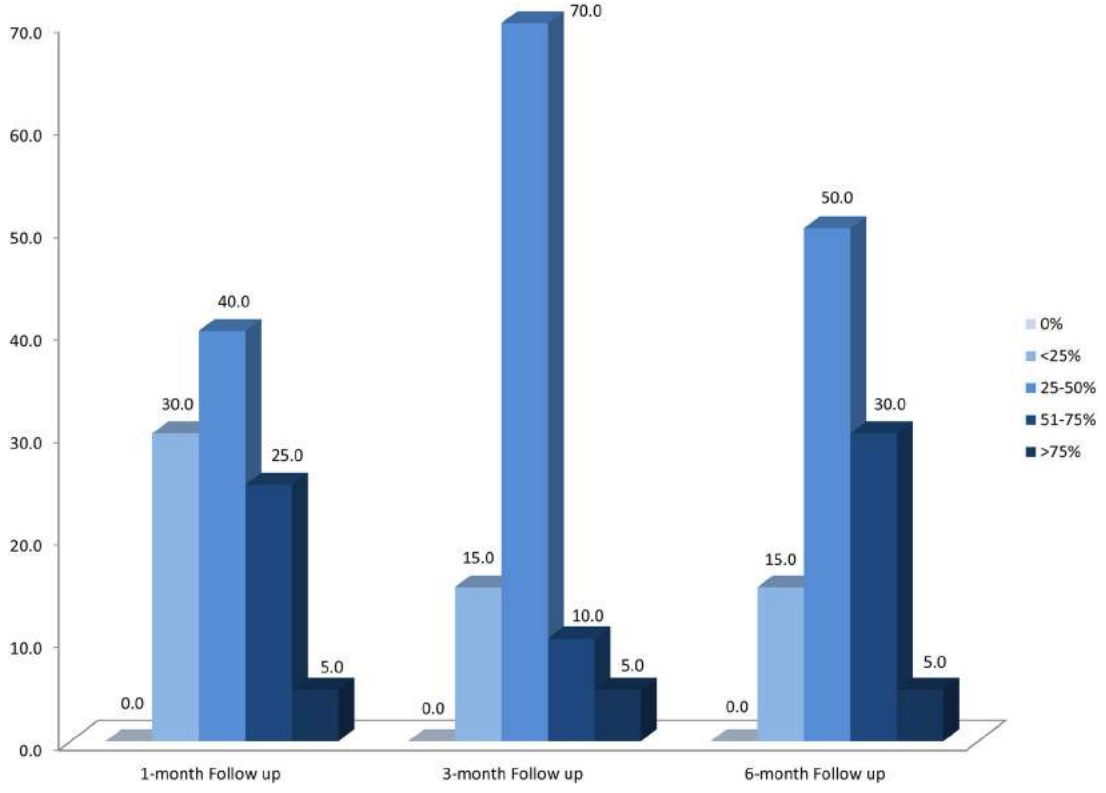

FIGURE 7 Patient satisfaction rating

reported itching for an average duration of 2.16 ± 0.71 days. Two subjects (10%) developed postinflammatory hyperpigmentation (PIH), which resolved within an average of 7 weeks after application of hydroquinone 4% cream (Figure 3).

4 | DISCUSSION

Despite the various available treatments for striae alba, the management of this condition still proves to be a challenge because of variable treatment outcomes. Lasers and energy-based devices (EBDs) represent noninvasive methods that can successfully stimulate the production of collagen and elastin that are believed to overcome the pathogenesis of striae alba. Among the variety of laser and light therapies available, fractional lasers exhibit the most promising outcomes in the improvement of striae alba appearance through repigmentation and collagen stimulation.[2] However, the main adverse effect of lasers and EBDs is PIH, especially in dark-skinned individuals, with an incidence of 36% in nonablative fractional laser (1550-nm fractional Er:glass laser)[22] and as high as 96% in ablative fractional laser (fractional CO_2 laser).[23] It is noteworthy in this study that the incidence of transient (an average of 7 weeks) PIH following fractional 1064-nm picosecond laser in patients with FSTs IV–V was as low as 10%. This is in accordance with the elevation of MI at 1-month follow-up and its improvement in the succeeding follow-up visits (Figure 4).

The present study demonstrated significant improvement of skin texture starting at 1 month after the final (fourth) fractional 1064-nm picosecond laser treatment, and continuously improved until the 6-month follow-up visit. This observation is in line with our previous studies demonstrating the continuous improvement following fractional CO_2 and Er:YAG lasers,[24] and fractional 1064-nm picosecond laser[14] for treatment of atrophic acne scars, which implies that dermal remodeling is a continuous process. Although no significant decrease in the melanin variation was noted, there was a trend toward melanin variation reduction from baseline throughout the 6-month follow-up visit, suggesting that there was more evenness of striae color after treatment.

There have been few published studies using fractional picosecond lasers for striae alba in light-skinned patients. Zaleski-Larson et al.[21] compared fractional 1565 nm Er:glass laser with a combination of fractional picosecond 1064 and 532 nm laser in the treatment of striae alba. The laser treatments were done in three sessions at 3-week intervals in a split-body design and demonstrated 31% texture improvement for both laser types. The degree of atrophy was improved by 30% for the fractional 1565 nm Er:glass laser and 35% for the fractional picosecond 1064/532 nm Nd:YAG lasers. The results were similar to our study that utilized a fractional picosecond 1064-nm Nd:YAG laser resulting in overall clinical and striae textural improvement. However, it must be noted that the outcome evaluation methods were different and the energy setting in our study was relatively lower but with more treatment sessions performed. Our study showed a shorter healing time, but with more pronounced PIH in patients with darker skin types. In darker skin types, LIOB was found to be larger and more numerous due to increased melanin content. Asian skin generally expresses larger melanosomes and a greater percentage of individual melanosomes compared with Caucasian skin. These differences may increase the incidence of PIH in this population.[25,26]

A previous retrospective study by Haimovic et al.[27] demonstrated the safety of a fractional 755-nm picosecond laser for many skin conditions including atrophic and hypertrophic scars, pigmented lesions, and striae in patients with FSTs IV–VI. Transient side effects such as erythema, edema, crusting, and scabbing usually resolved within a few days, which were similarly observed in our study. PIH also occurred in nearly the same percentage (10.7%) of study participants as our study, which may be due to the FSTs of the patients enrolled.

Another earlier split-body study by Yang and Lee[22] showed comparable therapeutic outcomes of a 1550 nm, fractional Er:glass laser and ablative fractional CO_2 laser resurfacing for the treatment of SD in volunteers with FST IV. However, the incidence of PIH was higher on the site treated with ablative fractional laser as mentioned earlier. A recent study on a microneedling device revealed at least 50% improvement of SD after an average of 1.8 treatments in light and dark skin tones on various body locations with side effects limited to transient erythema in all skin phototypes.[28]

Various forms of RF have been used for the treatment of SD, often in combination with other treatment methods.[29] Fractional RF appears to be the most efficacious, with some combination treatments such as platelet-rich plasma and topical retinoic acid offering further synergistic benefits.[30] By employing bipolar RF in combination with infrared light, Harmelin et al.[31] achieved significant improvement in the overall depth of SD, skin texture, and laxity.

The limitations in our study include small sample size and no histological investigation. Comparing the effects of different treatment parameters may optimize the treatment protocol. Building upon the findings of this study, combination treatments with other modalities and the use of laser-assisted drug delivery may be recommended for future research. In addition, patients' expectations of the treatment outcomes should be appropriately set at the initial counseling visit as the treatment of SD can be costly due to the large area of involvement and multiple sequential treatment sessions required to produce good outcomes.

In conclusion, the use of a fractional 1064-nm picosecond laser is effective and well-tolerated with minimal risk of transient adverse effects for the treatment of striae alba in dark-skinned individuals.

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CONFLICT OF INTERESTS

The authors declare that there are no conflict of interests.

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