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Comparative Analysis of Laser Therapies for Striae Distensae: Fractional CO_2 vs Combined Q-Switch Nd:YAG

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Statistical Analysis C
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Background: Striae, or stretch marks, are dermal scars caused by skin stretching, including striae rubrae (SR) and striae albae (SA), which are difficult to treat. Various lasers, including fractional carbon dioxide (CO_2) and Q-switched neodymium-doped yttrium aluminum garnet (Nd:YAG) lasers, have shown varying success rates. This study compared the efficacy of fractional CO_2 laser alone and in combination with Q-switched Nd:YAG laser in treating SR and SA.

Material/Methods: In each patient fractional CO_2 laser was applied alone to the randomly selected 4 striae distansae (SD) on one side of the body in Group 1 (n: 49), and Q-Switch Nd:YAG laser combined with fractional CO_2 laser was applied sequentially to the other 4 SD on the opposite side of the body in Group 2 (n=49). The number of SR, scores for color, vascularity, and atrophy were recorded. The largest measurable SD width and length were calculated. Global Aesthetic Improvement Scale score (GAIS), patient's subjective satisfaction score, and tolerability score were evaluated.

Results: Group 2 showed greater improvement in vascularity, atrophy, and SD dimensions compared to Group 1, but no significant differences in color. Reduction in SR count and GAIS scores was significantly higher in Group 2.

Conclusions: Combination treatment appears to be more effective in improving vascularity, atrophy, and the width and length of SD, resulting in higher patient satisfaction. We recommend to use Q-Switch Nd:YAG laser for the early stage of unmature SR and add fractional CO_2 laser for especially resistant markedly atrophic SA lesions after Q-Switch Nd:YAG laser.

Keywords: **Laser Therapy • Stria Vascularis • Striae Distensae**

Abbreviations: **BMI** – body mass index; **Er:YAG** – erbium-doped yttrium aluminum garnet; **FrCO_2** – fractional carbon dioxide; **GAIS** – Global Aesthetic Improvement Scale; **LP** – long-pulsed; **Nd:YAG** – neodymium-doped yttrium aluminum garnet; **PDL** – pulsed dye laser; **PIH** – post-inflammatory hyperpigmentation; **SA** – striae albae; **SD** – striae distensae; **SR** – striae rubrae; **SSS-p** – Patients' Subjective Satisfaction Score; **TS** – Tolerability Score; **VAS** – Visual Analog Scale

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Introduction

The origin of striae distansae (SD) is multifactorial and the exact etiopathogenesis of SD still remains controversial. Striae generally develop in various physiological states such as pregnancy, growth spurt during puberty, or rapid change in proportion of specific body regions such as in weight lifters, obesity, or weight loss [1]. Other factors like genetic predisposition, mechanical stress, and hormones, especially corticosteroids (both topical and systemic), also play an important role in SD formation. Hypercortisolism like Cushing's syndrome, and genetic disorders such as Marfan syndrome, drugs such as local or systemic corticosteroid therapy can also cause SD. Striae distensae occur in pregnancy (43% to 88%), puberty (6% to 86%), and obesity (43%) [1]. A positive family history is a risk factor for SD. During pregnancy, SD are more common in younger women than in older women [1].

Striæ distensae may initially appear as edematous striations that evolve to the red-to-purple, flat, or atrophic plaques known as striae rubrae (SR) that eventually progress to striæ albae (SA), which are hypopigmented, scar-like depressions with fine wrinkling. This progression often occurs over the course of 6 to 10 months. striae albae persist indefinitely and may become more prominent with age as the skin thins and loses additional elasticity [1,2].

In the early stage of SR, several treatments are available to improve their appearance, including topical tretinoin, microdermabrasion, mesotherapy, micro-needling, radiofrequency, photothermolysis, carboxytherapy, intense pulsed light, ablative and non-ablative lasers, and fractional lasers; however, no consistently effective treatment modality has been established [2,3]. Lasers have recently emerged as an alternative treatment, but studies have reported conflicting results and adverse effects, such as post-inflammatory hyperpigmentation (PIH) and persistent erythema [4]. Heat-based devices and lasers combined with adjuvant mesotherapy protocols are currently among the most popular treatment practices [4]. Due to the variety of available laser devices and the differing parameters reported in the literature, the optimal laser for treating striae SD remains unclear.

Fractional carbon dioxide ($FrCO_2$) laser (10 600 nm) has been shown to stimulate dermal collagen production and has been successfully used in the treatment of wrinkles, atrophic scars, and striae gravidarum, as well as for skin rejuvenation [4-6]. Q-Switch neodymium-doped yttrium aluminum garnet (Nd:YAG) laser (1064 nm) has been used for pigmentation disorders, tattoo removal, and persistent erythema [7,8]. It is also effective for skin rejuvenation, collagen stimulation, skin tightening, and toning [9]. Reports on the success of picosecond lasers and long-pulsed (LP) Nd:YAG lasers for SD treatment suggest that the Q-Switch Nd:YAG laser can also reduce the brightness and erythema of SR [10-12]. Given that SA share clinical and histological similarities with atrophic scars, and SR resembles pigmented, vascular erythematous tissue, the combination of Q-Switch Nd:YAG and $FrCO_2$ lasers could be effective for both. Therefore, this study aimed to compare the efficacy of the $FrCO_2$ laser alone and in combination with the Q-Switch Nd:YAG for the treatment of SR and SA.

Material and Methods

Patient Selection and Randomization of SD

Approval for the study was obtained from the Ethics Committee of Recep Tayyip Erdogan University Training and Research Hospital (number: 2025/35). Informed consent was obtained from all participants after receiving approval of the experimental protocol from the ethics committee. This study included 392 SD lesions from 49 volunteer patients aged 20 to 45 years, with Fitzpatrick skin phototype II-IV and SD on the abdomen, inner arms, breasts, hips, calves, lumbar region, and buttocks. Sex, age, history of SD during pregnancy, familial history of SD, SD localization and duration, body mass index (BMI), and Fitzpatrick skin phototype were recorded.

The Fitzpatrick scale includes 6 skin phototypes. Patients with type 1 always sunburn, never tan (palest, freckles), and have very light or white "Celtic" type skin. Type 2 means they usually sunburn, tan minimally (light colored but darker than pale), and have light or light-skinned European-type skin. Type 3 means they sometimes mildly sun burn, tan uniformly (golden honey or olive), and have light-intermediate or dark-skinned European-type skin. Type 4 means they burn minimally, always tan well (moderate brown), and have dark-intermediate or "olive skin". Type 5 patients burn very rarely, tan very easily (dark brown), and have dark or "brown" skin. Type 6 means they never burn (deeply pigmented dark brown to darkest brown) and have very dark or "black" skin [13].

Patients with a history of keloids or hypertrophic scars, malignancy, or systemic diseases and pregnant women were excluded from the study. Slightly raised, erythematous to bluish, pink or violaceous linear marks were accepted as SR, which fade over months to years. Besides flattened, hypopigmented, whitish colored, wrinkled SD with atrophic surface that follows the lines of cleavage were confirmed as SA [2] (**Figures 1, 2**).

If a patient had symmetrical abdominal SD lesions on the abdomen, these were included; otherwise, symmetrical extra-abdominal SD lesions were selected. Eight SD lesions consisting of either SR or SA were identified on each patient. Four SD on the right side of the body were randomly assigned to Group 1

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Figure 1. Hypopigmented, whitish colored, atrophic, wrinkled stretch marks confirmed as SA on the inner thigh of an overweight male patient. SA – striae albae.



Figure 2. Slightly raised pink or violaceous linear marks accepted as SR on the inner upper arm of a female patient. SR – striae rubrae.

and 4 symmetrical SD were randomly accepted to Group 2, in each patient by the same dermatologist (**Figure 3**). All lesions were photographed with the same 3D camera before treatment.

In Group 1 (n: 49), an $FrCO_2$ laser was applied alone to 4 SD localized on the right half of the body in each patient. In Group 2 (n: 49), the Q-Switch Nd:YAG laser was applied in combination with the $FrCO_2$ laser to the other 4 SD on the opposite left side of the body in each patient. The treatment areas were cleaned with an alcohol swap, and topical anesthesia was applied for 30 minutes under occlusion. Before the procedure, SD areas were wiped with wet gauze to remove the anesthetic cream. Informed consent was obtained from all patients prior to treatment.

Laser Application Procedure

For Group 1, the $FrCO_2$ laser (Fraxis Duo Illoda®) was applied with round pulses, using a spot size of 4.5 mjoules, i-stack 3, and pulse distance of 0.7 mm, with a single pass, by adjusting the spot size according to the SD diameter. For Group 2, first the Q-Switch Nd:YAG laser (Fotona Starwalker MaQX® super-pico laser, 1064 nm) was applied in full-beam mode with 1.8-2 joules/cm^2 fluence, 8 mm spot size, and 10 hertz, using an R28-D handpiece for 3 passes. This was followed by the super-pico laser in fractional mode at 86 Joule/cm^2 fluence, 9X9 spot



Figure 3. Four SD lesions on each side of the body were randomly marked and assigned to either Group 1 or Group 2 in each patient. SD – striae distansae.

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size, 0.5 hertz with an FS20A handpiece for 2 passes. Cooling was also provided. The $FrCO_2$ laser (Fraxis Duo Illoda®) was then applied sequentially in the same session at the same doses as in Group 1, after wiping the application area with physiological saline-soaked gauze. The patients in both groups were treated every 4 weeks for a total of 3 sessions. All patients participating in the study were given necessary warnings about sun protection. Laser parameters were constant for all of the participants with different Fitzpatrick skin types and were accepted as safe. None of the patients had skin type more than type 4.

Morphological Evaluation

The presence and number of SR lesions were also noted for both groups (0-4) in each patient. The mean difference in the pre-and post-treatment SR counts was compared. Pre-treatment and post-treatment (first-month) clinical and dermoscopic evaluations included scores for stria color-brightness (0-3), vascularity (0-3), and atrophy (0-4). The largest measurable width and length (mm) were calculated. Mean differences in vascularity, color, atrophy, SD width, and SD length were analyzed. Photographs were taken using a Leofarma® digital dermoscopy camera (×20) before and after treatment for an objective assessment. Adverse effects such as PIH, prolonged or persistent erythema, scarring, telangiectasia, irritation, pain, and infection were documented. One SD lesion in the photograph was automatically marked using a straight line along the SD using the Image Meter software, and the width and length of the SD were measured on the computer.

Clinical Efficacy and Side Effects Analysis

At week 16, the Global Aesthetic Improvement Scale (GAIS) (physician version) score, clinical response rate, patient's subjective satisfaction score (SSS-p), Visual Analog Scale (VAS) score for pain, and tolerability score (TS) were measured in both groups. GAIS scores were also compared for patients with SR in both groups. Using GAIS, a 5-point scale (0-4), the researcher rated global esthetic improvement in appearance based on pre- and post-treatment photographs as "worse," "no change," "slight improvement," "significant improvement," or "very significant improvement" [14]. Clinical response rate was measured on a three-point scale: 1=poor (<33% visual improvement), 2=moderate (33-66% visual improvement), and 3=good (≥66% visual improvement). SSS-p was evaluated using a five-point Likert scale (0-4): 4=very satisfied, 3=satisfied, 2=neutral, 1=dissatisfied, and 0=very dissatisfied. Treatment tolerability was rated on a scale of 1 to 4: 4=very well tolerated, 3=tolerable, 2=difficult to tolerate, and 1=not at all tolerable.

Statistical Analysis

Statistical analyses were performed using SPSS version 26.0 for Windows. Descriptive measures were presented as mean and standard deviation values and percentage distributions. The conformity of the data to the normal distribution was checked using the Shapiro-Wilk test. The Wilcoxon test was used to compare continuous variables, and the McNemar chi-square analysis was used to compare distributions. The significance level was taken as $p<0.05$.

Results

Demographic Data

Of the 49 patients participating in the study, 18 (36.7%) were male, and 31 (63.3%) were female, with a mean age of 29.8±8.7 years. Eleven of the 13 patients (84.6%) with a history of pregnancy had experienced SD during pregnancy. Accompanying SR was detected in 31 patients (63.3%). A total of 392 SD lesions were evaluated. Regarding the distribution of SD lesions, 29 patients (59.2%) had lesions on the abdomen, 19 (38.8%) on the inner arms, 12 (24.5%) on the breasts, 32 (65.3%) on the hips, 24 (49%) on the calves, 32 (65.3%) on the lumbar region, and 36 (73.5%) on the buttocks. Among the patients, 17 had Fitzpatrick skin type 2, 22 had skin type 3, and 10 had skin type 4. Based on BMI, 3 (6.1%) patients were underweight, 15 (30.6%) had a normal weight, 14 (28.6%) were overweight, 12 (24.5%) were obese, and 5 (10.2%) were severely obese. The duration of SD was less than one month in 2 patients (4.1%), 1-6 months in 9 patients (18.4%), 6 months-1 year in 10 patients (20.4%), 1-5 years in 14 patients (28.6%), and more than 5 years in 14 patients (28.6%).

Morphological Features

In both groups, post-treatment scores for color, vascularity, and atrophy were statistically significantly lower compared to pre-treatment scores ($p<0.001$). The difference in pre- and post-treatment vascularity scores was statistically significantly higher in Group 2 than in Group 1. However, no significant difference was noted between the 2 groups in terms of color score changes ($p=0.092$). Regarding atrophy, Group 2 showed a statistically significantly greater improvement than Group 1 ($p<0.001$). Overall, the combination of the Q-Switch Nd:YAG laser with the $FrCO_2$ laser was more effective than the $FrCO_2$ laser alone in improving vascularity and atrophy, although both groups exhibited similar results in terms of color (**Table 1**).

Width and Length Analysis of SD

In Group 1, the mean SD width decreased from 3.39±1.08 mm at week 0 to 2.35±1.17 mm at week 16 ($p<0.001$). In Group 2, the mean SD width decreased from 3.61±1.09 mm at week 0 to 1.57±1.10 mm at week 16 ($p<0.001$). In both groups, the pre-treatment SD width was statistically significantly greater than the mean post-treatment SD width ($p<0.001$). The

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Table 1. The mean scores for morphological features in 2 groups at weeks 0 and 16 and the pre- and post-treatment score differences in terms of vascularity, color and atrophy.

Morphology of SD	Time	Group 1	Group 2	p-value
Vascularity score	Week 0 (pre-treatment)	2.27±0.64	2.14±0.74	
Vascularity score	Week 16 (post-treatment)	1.16±0.80	0.73±0.67	
p values		**<0.001**	**<0.001**	
Difference between pre- and post-treatment vascularity score		1.1±0.7	1.4±0.6	**<0.001**
Color score	Week 0 (pre-treatment)	2.47±0.77	2.35±0.75	
Color score	Week 16 (post-treatment)	1.31±0.89	0.98±0.78	
p values		**<0.001**	**<0.001**	
Difference between pre- and post-treatment color score		1.2±0.7	1.4±0.7	**0.092**
Atrophy score	Week 0 (pre-treatment)	2.53±0.82	2.78±0.82	
Atrophy score	Week 16 (post-treatment)	1.90±0.94	1.08±0.86	
p values		**<0.001**	**<0.001**	
Difference between pre- and post-treatment atrophy score		0.6±0.6	1.7±0.6	**<0.001**

Group 1: fractional CO_2 laser alone, Group 2: Q-Switch Nd:YAG laser + fractional CO_2 laser. Values are presented as mean±standard deviation. SD – striae distensae.

Table 2. The width and length of SD in Group 1 and Group 2 at weeks 0 and 16 and the comparison of the differences in SD width and length values between 2 groups.

	Group 1	Group 2	p values
SD width at week 0, mm	3.39±1.08	3.61±1.09	
SD width at week 16, mm	2.35±1.17	1.57±1.10	
p-value	**<0.001**	**<0.001**	
Difference in SD width, mm	1.1±0.8	2.1±0.9	**<0.001**
SD length at week 0, mm	45.5±13.7	48.0±14.4	
SD length at week 16, mm	37.1±11.9	33.9±11.3	
p-value	**<0.001**	**<0.001**	
Difference in SD length, mm	8.4±5.3	14.1±6.9	**<0.001**

Group 1: fractional CO_2 laser alone, Group 2: Q-Switch Nd:YAG laser + fractional CO_2 laser. Values are presented as mean±standard deviation. SD – striae distensae.

reduction in SD width in Group 2 was statistically significantly greater than in Group 1 (p<0.001) (**Table 2**).

In Group 1, the mean SD length decreased from 45.5±13.7 mm at week 0 to 37.1±11.9 mm at week 16 (p<0.001), while in Group 2, the mean SD length decreased from 48.0±14.4 mm to 33.9±11.3 mm during the same period (p<0.001). As with SD width, the reduction in SD length was statistically significantly greater in Group 2 than in Group 1 (p<0.001) (**Table 2**).

Thus, the combined laser treatment was more effective than the $FrCO_2$ laser alone in reducing SD width and length.

Clinical Efficacy Results

In both groups, the number of SR lesions significantly decreased after treatment compared to before treatment (p<0.001). The reduction in the number of SR lesions was significantly higher in Group 2 than in Group 1 (**Table 3**).

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Table 3. The mean number of SR at weeks 0 and 16 in Group 1 and Group 2 and the comparison of the mean difference in pre- and post-treatment SR counts between 2 groups.

Number of SR	Group 1 (n)	Group 2 (n)	p-value
Week 0	1.59±1.59	1.92±1.67	
Week 16	0.63±1.04	0.35±0.69	
p-value	**<0.001**	**<0.001**	
Mean difference in pre-and post-treatment SR counts	1.5±0.8	2.5±1.2	**<0.001**

Group 1: fractional CO_2 laser alone, Group 2: Q-Switch Nd:YAG laser + fractional CO_2 laser. Values are presented as mean±standard deviation. SR – striae rubrae.

Table 4. Comparison of the clinical efficacy, patient satisfaction and tolerability between Group 1 and Group 2.

	Group 1 (n)	Group 2 (n)	p-value
Mean GAIS score	1.22±0.92	1.86±1.06	**<0.001**
Mean GAIS among patients with SR	1.55±0.85	2.16±1.00	**<0.001**
Mean clinical response rate	1.57±0.68	2.06±0.83	**<0.001**
Patient's subjective satisfaction score	2.12±1.29	2.78±1.18	**<0.001**
Mean VAS pain score	2.90±1.31	5.31±1.69	**<0.001**
Mean tolerability score	3.69±0.51	3.33±0.83	**<0.001**

Group 1: fractional CO_2 laser alone, Group 2: Q-Switch Nd:YAG laser + fractional CO_2 laser. Values are presented as mean±standard deviation. GAIS – Global Aesthetic Improvement Scale; SR – stria rubrae; VAS – Visual Analog Scale.



Figure 4. The significant reduction in the number of SR and good clinical response in Group 2 treated with 3 sessions of fractional CO_2 laser combined with Q-Switch Nd:YAG laser. SR – striae rubrae.

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The mean GAIS scores, clinical response rate, and SSS-p scores were all statistically significantly higher in Group 2 compared to Group 1 (p<0.001) (**Table 4; Figure 4**). Among patients with SR, the mean GAIS was statistically significantly higher in Group 2 than in Group 1 (p<0.001). In terms of GAIS, 13 patients in Group 1 and 2 in Group 2 showed a worse response; 15 patients in Group 1 and 21 in Group 2 showed no change; 18 patients in Group 1 and 12 in Group 2 showed slight improvement; and 3 patients in Group 1 and 10 in Group 2 showed significant improvement. A very significant improvement was seen in only 4 patients in Group 2. Clinical response in Group 1 was poor in 26 patients (53.1%), moderate in 18 (36.7%), and good in 5 (10.2%). In Group 2, the clinical response was poor in 15 patients (30.6%), moderate in 16 (32.7%), and good in 18 (36.7%).

Adverse Effects

Adverse effects were observed in 8 patients. PIH was detected in 8 patients (16.3%), prolonged/persistent erythema in 5 (10.2%), irritation in 5 (10.2%), and pain in 3 (6.1%). No significant difference was noted between the 2 groups in terms of adverse effects. The mean VAS score was 2.9±1.3 in Group 1 and 5.3±1.7 in Group 2, with statistically significantly higher pain levels reported in Group 2 (p<0.001). Lastly, the mean TS was statistically significantly higher in Group 1 than in Group 2 (p<0.001) (**Table 4**).

Discussion

The results of this study show that the clinical efficacy of the Q-Switch Nd:YAG laser combined with the $FrCO_2$ laser exceeded that of the $FrCO_2$ laser alone in the treatment of both SR and SA. However, the risk of PIH associated with ablative lasers, even when used in fractional mode, should not be overlooked, particularly in dark-skinned patients. The similarity in adverse effects between the 2 groups in this study also confirms the relative higher risk of PIH, especially with the $FrCO_2$ laser. The combination of the $FrCO_2$ laser with the Q-Switch Nd:YAG laser was not only slightly more effective in reducing vascularity and atrophy, but it also improved the appearance of bright reddish SR compared to the $FrCO_2$ laser alone. Furthermore, the addition of the Q-Switch Nd:YAG laser to the $FrCO_2$ laser yielded promising results in improving the atrophic appearance of long-standing SA.

Since some SD may appear red-purple in their early stages, further investigation of the effect of the Q-Switch Nd:YAG laser is warranted, especially for the treatment of red-purple or bluish pigmented, vascular-like newly emerging SR. Although the Q-Switch Nd:YAG laser has been mentioned in a few reviews, no prospective, randomized, split-body, comparative studies have specifically examined their efficacy for SD. The current study is noteworthy because it included patients of both sexes with variable BMI, different skin phototypes, and both long-standing and acutely appearing SR lesions, including extra-abdominal involvements, such as the buttocks, calves, posterior knees, inner arms, and breasts.

Treating SD remains a challenge for physicians, even when patients have realistic expectations. Various therapeutic strategies are available, but no single modality has proven to be solely effective. Laser treatments target different chromophores such as water, hemoglobin, and melanin, improving the appearance of SD by stimulating collagen production, decreasing vascularity (especially in SR), and increasing melanin pigmentation. Both ablative lasers (eg, 10 600-nm CO_2 laser and 2940-nm Erbium-doped yttrium aluminum garnet [Er:YAG] laser) and non-ablative lasers (eg, 585-nm pulsed dye laser [PDL], 1,540-nm Erbium glass laser, and 1,064-nm LP Nd:YAG laser) have been tried with varying success rates in the management of SD [4,5,7,10-13,15-19]. Hybrid laser systems, which combine ablative and non-ablative lasers, have been shown to provide safe and effective results for SD with minimal downtime, regardless of patient characteristics such as skin type and body region. There is, however, a weak negative correlation between the outcomes of these treatments and patient age [14].

The Q-Switch Nd:YAG laser, also used for skin toning, pore and vascular treatment, collagen remodeling, and anti-aging purposes, delivers very short pulses of less than a billionth of a second (in nanoseconds or picoseconds) [9,10,13]. These high-intensity pulses break down melanin or vascular pigment particles without damaging surrounding tissues, thereby minimizing the risk of side effects [20]. The homogeneous distribution and very short-duration pulses of this laser increase the efficacy of treatment [21]. Millisecond Q-Switch lasers are often one of the first choices for treating vascular lesions and telangiectasias, with a lower recurrence rate reported in studies [22]. Telangiectasias and skin laxity caused by ultraviolet damage respond particularly well to treatment with Q-switched 1064 nm lasers [23]. Recently, a new generation of high-energy emission, micro-ablative 1,064 nm Q-Switch Nd:YAG lasers, operating within nanosecond and picosecond pulse durations, has demonstrated the ability to drill precise micro-holes through skin tissues [24]. Their biological action relies on high-intensity photo-acoustic light-tissue interaction, with minimal collateral photo-thermal effects. This innovative form of ablative fractional remodeling has shown extremely promising clinical results in both hypotrophic and hypertrophic scars, as well as in SD treatments, with fewer post-treatment chromatic adverse effects [25]. Ablative fractional remodeling can also be effectively used to increase transcutaneous penetration of active agents, regardless of their molecular size [25].

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It is considered that the dilated, reddish-purple venules and perivascular infiltrates present in SD lesions may be desirable targets for the Q-Switch Nd:YAG laser due to their vascular pigment content. In this study, the significant reduction in the number of SR lesions and the higher GAIS scores among patients with SR in Group 2 suggest the additional efficacy of the Q-Switch Nd:YAG laser for SR. Measuring the width and length of SR lesions in both groups could provide further valuable data on the potential positive effects of the Q-Switch Nd:YAG laser in patients with SR.

For effective SD treatment, lasers should not only promote neocollagenesis but also reduce erythema in SR and improve pigmentation in SA [3]. Several laser types, including PDL and Nd:YAG lasers, target vascular chromophores in SR and blue-purple SD, and they have been shown to reduce redness and swelling [11,12,15,17,18]. Treatment outcomes for the $FrCO_2$ laser have been enhanced when combined with PDL [17]. In a previous split-body comparative study 88 SA lesions in 3 female patients were striae either treated by fractional CO_2 laser resurfacing and or by a combination of PDL and fractional CO_2 laser, alternately [17]. The mean surface area decreased significantly in both groups after treatment. The mean difference between the pre- and post-treatment surface area was significantly higher in the combination treatment group; 0.62±053 versus 0.41±0.43 [17]. Mean VAS and dermatologist assessed improvement scale were both found to be significantly higher in fractional CO_2 laser and PDL combination group. The combination of PDL and fractional CO_2 laser was reported to be more effective than fractional CO_2 laser alone in the treatment of SA [17]. This previous study, similar to our study, confirms the conclusion that combination therapy with fractional CO_2 laser is more effective in the treatment of SA. In a study comparing the $FrCO_2$ laser to the non-ablative 1,540-nm Erbium glass laser for SD, both were found equally effective, but the latter was better tolerated by patients [16].

As a melanin chromophore-targeting laser, some anti-pigmentation lasers, such as the picosecond Nd:YAG laser (1064 nm), have also been reported to improve SD [12,19]. In a study by Fusano et al, 81.4% of patients showed clinical improvement in SA after 4 months of treatment with a 1064-nm picosecond laser [12]. However, no significant reduction in SD width or improvement in collagen remodeling and dermal papillae was observed with reflectance confocal microscopy, indicating that while the 1064-nm picosecond laser may be effective for SA, it is not a complete cure [12]. In a later study including 20 dark-skinned (Fitzpatrick types IV-V) patients with SA, over 90% reported moderate to significant improvement in skin texture and color evenness 6 months after treatment with the 1064-nm picosecond laser [19]. However, ablative lasers are associated with severe erythema, post-procedural pigmentation, and prolonged downtime [3], whereas fractional and non-ablative lasers generally result in minimal downtime and better patient compliance.

The ablative $FrCO_2$ laser is the most commonly used laser for the treatment of SD and has demonstrated satisfactory efficacy in promoting collagen and elastin regeneration and remodeling [4,6]. In a study by Crocco et al, 13 patients with striae gravidarum showed a significant reduction in the width of their largest SD lesions, along with significant thickening of the epidermal cell layer and increased collagen fibers, after treatment with a 10 600-nm $FrCO_2$ laser [6]. However, the higher the laser energy, the greater the risk of PIH, which in some cases can persist for up to a year [4]. Studies have also shown comparable efficacy between the $FrCO_2$ laser and micro-needling for SR [26]. In a previous study 48 pairs of SA from 6 patients were randomly selected and SA's were randomly assigned to be treated with either fractionated microneedle radiofrequency (FMR) alone in Group 1 and combination with fractional carbon dioxide laser ($FMR+CO_2$) in Group 2 [27]. The mean difference of the surface area between pre- and post-treatment and clinical improvement scales in the $FMR+CO_2$ group were found to be significantly higher than that in the FMR group. Thus, similar to our study the combination of FMR and CO_2 laser was found to be more effective than FMR alone in the treatment of SA [27].

Some studies with conflicting results regarding the efficacy of non-ablative lasers in the treatment of SD are also noteworthy. In a study conducted by Elsaie, the LP Nd:YAG laser at 75 joules/cm^2 resulted in significant improvement in 45 patients with skin types III-V [10]. The LP Nd:YAG laser, which has a strong affinity for vascular structures, increases dermal collagen and improves immature SD [11]. In addition, Hendawy et al found the long-pulsed Nd:YAG laser to be more effective than the $FrCO_2$ laser for treating SD, with fewer serious adverse effects, despite the minimal histological difference between the 2 lasers [11]. These findings support the use of the LP Nd:YAG laser for SD, as the $FrCO_2$ laser was associated with a higher incidence of side effects. However, a study by Güngör et al concluded that neither the LP Nd:YAG laser nor the 2,940-nm variable square pulse Erb: YAG laser was effective in treating SD [18]. Although some positive results were noted regarding collagen and elastin fibers, they were not statistically significant [18]. Based on these contradictory results, non-ablative lasers may not be sufficient, especially for treating SA when used alone.

Given the above-mentioned findings from the literature, the current study investigated the efficacy of combining a non-ablative laser (1064 nm Q-Switch Nd:YAG) with an ablative laser ($FrCO_2$) in the treatment of SD. Combining short-pulse 1,064-nm lasers with ablative or non-ablative laser-assisted tissue remodeling has been previously shown to effectively reduce

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the vascular component associated with the active proliferation of fibrotic tissue in keloid scars [28]. Using the short-pulse 1,064-nm laser before ablative or non-ablative fractional laser remodeling has been reported to contribute to increased tissue temperature and act as a biological primer on dermal fibroblasts, leading to improved clinical results in skin aging, atrophic scars, and SD [28].

Study Limitations

We believe that the lack of the evaluation of variable laser parameters including different doses and pulse durations and the lack of the clinical results in terms of different Fitzpatrick skin types were limitations of our study. The SD localized on sun exposed areas may have also acted on the clinical results. Although we found a significant better response with the combination laser treatment on SR, the further evaluation of the specific morphological features such as vascularity and color on SA and SR separately would be scientifically more valuable.

Conclusions

For effective SD treatment, a comprehensive patient evaluation is crucial, including a thorough history, SD type, and skin type assessment. Future studies should include well-designed clinical trials with larger sample sizes, longer follow-up periods, and comparisons of different laser parameters, skin types, and SD locations to better address the issue of the optimum laser management of SD.

It is recommended to combine the $FrCO_2$ laser with the Q-Switch Nd:YAG or another non-ablative laser to achieve better outcomes in the treatment of SD lesions. This combined treatment strategy may further enhance collagen remodeling and elastic fiber production, particularly in patients with SA. This study showed that the combination of the Q-Switch Nd:YAG laser with the $FrCO_2$ laser yielded superior results in reducing SD vascularity and atrophy compared to the $FrCO_2$ laser alone. In the very early stages of SR, specifically in immature lesions, the Q-Switch Nd:YAG laser may also be an effective first-line treatment to diminish redness and vascularity. Overall, the combination treatment appears to be a better choice for both SR and SA, particularly in addressing vascularity, atrophy, SD width, and SD length, ultimately leading to higher patient satisfaction.

Declaration of Figures' Authenticity

All figures submitted have been created by the author who confirms that the images are original with no duplication and have not been previously published in whole or in part.

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