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REVIEW ARTICLE

Comparative study between the efficacy of fractional micro-needle radiofrequency and fractional CO_2 laser in the treatment of striae distensae

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Abstract

Striae distensae (SD) cause a cosmetic problem to many patients. Recently, fractional micro-needle radiofrequency (FMR) device has been introduced in treatment of SD. Also, fractional CO_2 laser has been used as a resurfacing laser technique in the treatment of SD. The aim of our study was to assess and compare between the efficacy of FMR and fractional CO_2 laser in treatment of SD. Seventeen female patients with SD were enrolled in this study. Detailed history was taken and dermatological examination was done to determine the type of striae, the location, and measurement of the width of the largest striae on each side. In each patient, one side was randomly assigned to treatment by FMR (area A), and the other side to treatment by fractional CO_2 laser (area B). Our results showed that both techniques were effective. A slight better efficacy was encountered with FMR, but the difference was not statistically significant ($p = 0.716$). The current study concluded that FMR and fractional CO_2 laser are almost equally effective in the treatment of SD (rubra and alba). Development of post inflammatory hyper-pigmentation (PIH) was evident with fractional CO2 in contrast with FMR, and the difference was statistically significant ($p = 0.001$).

Keywords Striae distensae · Fractional micro-needle radiofrequency · Fractional CO_2 laser

Introduction

Striae distensae (SD) or stretch marks are common dermal lesions, which arise due to the stretching of the dermis. There are two forms of SD: striae rubrae and striae albae. The acute stage (striae rubrae) is characterized by the initial erythematous, red and stretched flat (in some cases appear slightly raised) lesions, and the chronic stage (striae albae) is characterized by faded, atrophic, wrinkled, and hypopigmented SD [1]. Striae may result from a number of causes, including rapid changes in weight, adolescent growth spurts, corticosteroid use, or Cushing's syndrome. They generally appear on the buttocks, thighs, knees, calves, or lumbosacral area. In addition, approximately 90% of all pregnant women develop stretch marks either on their breasts and/or abdomen by the third trimester. Genetic predisposition is also presumed to have a role in the development of SD [2, 3]. Several treatments have been advocated with variable efficacy. These include topical creams such as tretinoin, which is believed to cause fibroblast stimulation and increased collagen production and angiogenesis in SD [4]. Also, topical glycolic acid in different concentrations (20–70%) and trichloroacetic acid (TCA) in low concentrations (10–35%) have been used in the treatment of SD [5]. More recently, fractional CO_2 laser has been introduced as a newer resurfacing technique in treatment of SD. Fractional CO_2 forms micro-thermal zones (MTZ) of damage. The necrotic debris is expelled and neo-collagenesis occurs. Accordingly, fractional CO_2 laser stimulates epidermal turnover and dermal collagen remodeling. It is reported to improve texture and appearance of the striae [6]. Also, fractional micro-needle radiofrequency (FMR) device has been used in the treatment of SD. Its mechanism of action is thought to be related to the fact that water, collagen, melanin, and the dermal microvasculature can absorb energy from the device, producing a bulk heating effect in the dermis that in turn induces growth factor secretion such as VEGF, FGF, resulting in dermal remodeling [7]. The aim of our work is to assess and compare between the efficacy of FMR and fractional CO_2 laser in treatment of SD.

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Patients and methods

Patients

The present study included 17 female patients with SD, which were recruited from the outpatient clinic of the Dermatology Department, Cairo University, from March 2017 to October 2017. An informed consent for treatment and photography was taken before enrollment, and it was approved by the Dermatology Research Ethical Committee (REC). Healthy female subjects, aged above 18, with SD without associated dermatological or systemic diseases were included in the study.

Exclusion criteria:

- Any treatment procedure for SD within 6 months prior to the study e.g. laser, radiofrequency, dermabrasion, chemical peeling etc.
- History of keloids or hypertrophic scars
- Pregnancy and lactation.
- Connective tissue disease, diabetes, skin infection, or any other disease, which could affect the wound-healing process
- Systemic retinoid use within 6 months of study initiation and/or use of immunosuppressive drugs

Protocol

History and dermatological examination were done to determine the type and location of SD and measure the width of the largest striae on each side. In each patient, one side was randomly assigned to treatment by FMR (area A) and the other side was assigned to fractional CO_2 laser (area B). Topical anesthesia (pridocaine cream 5%) was applied for 60 min under occlusion before either procedure. Each patient underwent 5 monthly sessions.

FMR was performed using VIVACE™, which combines microneedling with bipolar radiofrequency. Cartridges with 36 non-insulated micro-needles were used. Two passes were done in each session. The first pass was done along the length of striae and the parameters used were level 5, depth 3.5, and pulse time 400. The second pass was done on the whole affected area (striae and surrounding), and the parameters used were level 4, depth 3, and pulse time 300.

Fractional CO_2 laser was performed using DEKA Smartxide DOT. Two passes were done. The first pass was done along the length of the striae, and the parameters used were power 20 W, spacing 800 μm, dwell time 800 μs, and 3 stacks. The second pass was done on the whole affected area (striae and surrounding) using the following parameters: power 20 W, spacing 800 μm, dwell time 800 μs, and 2 stacks. Protective eye goggles were used during the sessions for both patients and the treating physician. Ice packs for cooling were immediately applied after the laser sessions.

The patients were advised to apply a topical antibiotic cream (fucidic acid 2% cream) twice daily and an emollient twice a day for a week after each session. Photographs were taken with a (I phone 6 s) digital camera (8 megapixel) before starting the treatment, at the beginning of every session and 1 month after the last session.

Outcome evaluation (Table 1)

Outcome was assessed 1 month after the last session relying on clinical examination and digital photos taken before and after treatment. The results were then evaluated based on:

- Measurement of the width of the largest striae on each side before and after treatment. A score was given (from 0 to 4) according to the percentage of width reduction
- One blinded physician's assessment of patients results score (from 0 to 4)
- Patient satisfaction score (from 0 to 4)
- Improvement in texture score (from 0 to 4)
- Overall appearance score (from 0 to 4)
- Sequelae: presence or absence of post inflammatory hyper-pigmentation score (PIH) (0–1)

Data management and statistical analysis

Data were coded and entered using the statistical package SPSS (Statistical Package for the Social Sciences) version 24. Data was summarized using mean, standard deviation, median, and minimum and maximum in quantitative data and using frequency (count) and relative frequency (percentage) for categorical data. For comparing categorical data, chi square ($\chi 2$) test was performed. Exact test was used instead when the expected frequency is less than 5. Correlations between quantitative variables were done using Spearman correlation coefficient [8]. *P* values less than 0.05 were considered as statistically significant.

Results

The demographic features of the patients are summarized in Table 2.

Table 1 Scoring grades used for clinical assessment score

	Percent of reduction of width of largest SD	One blinded physician's assessment	Patient satisfaction	Skin texture	Overall appearance	Sequalae (Presence of PIH)
0	No improvement	No improvement	No improvement	No improvement	No improvement	PIH present
1	Minimal improvement (< 25%)	Minimal improvement (< 25%)	Minimal improvement (< 25%)	Minimal improvement (< 25%)	Minimal improvement (< 25%)	No PIH
2	Good improvement (25–50%)	Good improvement (25–50%)	Good improvement (25–50%)	Good improvement (25–50%)	Good improvement (25–50%)	
3	Very good improvement (50–75%)	Very good improvement (50–75%)	Very good improvement (50–75%)	Very good improvement (50–75%)	Very good improvement (50–75%)	
4	Excellent improvement (> 75%)	Excellent improvement (> 75%)	Excellent improvement (> 75%)	Excellent improvement (> 75%)	Excellent improvement (> 75%)	

Area A (FMR) results

1—Width of the largest striae

Average of improvement in width of the largest striae was 44.29%. More detailed results are postulated in Table 3. The mean score was 2.35. We evaluated the factors that may affect the improvement of the width of the striae and no correlation was found with the age of the patient ($p = 0.713$), disease duration ($p = 0.255$), type of striae ($p = 0.833$), location of the striae ($p = 0.755$), or the skin type. Our results showed excellent improvement in one case with skin type III (16.7%); very good improvement in one case with skin type III (16.7%) and four cases with skin type IV (40%); good improvement in three cases with skin type III (50%), six cases with skin type IV (60%), and one case with skin type V (100%); and minimal improvement in one case with skin type III (16.7%).

Table 2 Demographic features of the patients Feature

Feature		Count	Percent
Duration of SD	< 12 months	5	30%
	> 12 months	12	70%
Type of SD	Alba	14	82.4%
	Rubra	3	17.6%
Location of SD	Abdomen	10	58.8%
	Thighs	5	29.4%
	Arms	1	5.9%
	Calves	1	5.9%
Cause of SD	Pregnancy	8	47.1%
	Weight gain	5	29.4%
Skin type	Steroid	4	23.5%
	III	6	35.3%
	IV	10	58.8%
	V	1	5.9%
Age of patient	< 25	5	30%
	> 25	12	70%

2—Patient satisfaction

The patient satisfaction questionnaire revealed good improvement in most patients (nine patients), excellent improvement in one patient, very good improvement in one patient, and minimal improvement in six patients. The mean score was 1.82.

3—The blinded physician evaluation

Evaluation of the results by a blinded physician showed excellent improvement in six patients, very good improvement in five patients, and good improvement in six patients. The mean score was 3. There was no correlation between the evaluation results and the patient age ($p = 0.913$), duration of the striae ($p = 0.599$), the type of the striae ($p = 0.322$), the location of the striae ($p = 0.683$), or the skin type. Our results showed excellent improvement in one case with skin type III (16.7%) and five cases with skin type IV (50%); very good improvement in two cases with skin type III (33.3%), two cases with skin type IV (20%), and one case with skin type V (100%); and good improvement in three cases with skin type III (50%) and three cases with skin type IV (30%).

4—Improvement in texture

The improvement of the texture of the striae was excellent in one patient, very good in one patient, good in nine patients, and minimal in six patients. The mean score was 1.82. There was no correlation between improvement in texture and the age of the patient ($p = 0.929$), duration of the striae ($p = 0.898$), type of the striae ($p = 0.877$), location of the striae ($p = 0.566$), or the skin type. Our results showed excellent improvement in one case with skin type IV (10%); very good improvement one case with skin type IV (10%); good improvement in two cases with skin type III (33.3%), six cases with skin type IV (60%), and one with skin type V (100%); and minimal improvement in four cases with skin type III (66.7%) and in two cases with skin type IV (20%).

Table 3 Percentage of reduction in the width of largest striae in area A

Patient number	Size of largest striae		Reduction in the width of the largest striae
	Before treatment	After treatment	
1	1.5 cm	0.9 cm	40%
2	0.7 cm	0.3 cm	57%
3	1 cm	0.4 cm	60%
4	0.9 cm	0.4 cm	55%
5	1.5 cm	1 cm	33%
6	0.5 cm	0.1 cm	80%
7	0.6 cm	0.2 cm	66%
8	0.3 cm	0.2 cm	30%
9	0.8 cm	0.3 cm	62%
10	1 cm	0.5 cm	50%
11	1 cm	0.7 cm	30%
12	0.4 cm	0. 2 cm	50%
13	1 cm	0.6 cm	40%
14	0.6 cm	0.5 cm	10%
15	0.9 cm	0.6 cm	30%
16	0.2 cm	0.1 cm	50%
17	0.5 cm	0.3 cm	40%

5—Overall appearance assessment

The overall improvement of the striae was assessed and revealed excellent improvement in five patients, very good improvement in five patients, and good improvement in seven patients (Fig. 1). The mean score was 2.88. There was no correlation between the overall improvement and the age of the patient ($p = 0.917$), duration of the striae ($p = 0.892$) nor the type of the striae ($p = 0.344$). Our results showed excellent improvement in four cases with striae albae (28.6%) and one case with striae rubrae (33.3%), very good improvement in four cases with striae albae (28.6%) and one case with striae rubrae (33.3%), and good improvement in six cases with striae albae (42.9%) and one case with striae rubrae (33.3%). There was no correlation with the location of the striae ($p = 0.688$). Our results showed very good improvement in two cases with striae on the abdomen (20%), two cases on the thighs (40%), and one case on the arms (100%); good improvement in five cases with striae on the abdomen (50%) and two cases with striae on the thighs (40%); minimal improvement in three cases on the abdomen (30%) and one case with striae on the thighs (20%); and no improvement in one case with striae on the calves (100%). No correlation was found with the skin type. Our results showed very good improvement in two cases with skin type III (33.3%) and three cases with skin type IV (30%); good improvement in one case with skin type III (16.7%), five cases with skin type IV (50%), and one case with skin type V (100%); minimal improvement in three cases with skin type III (50%) and one case with skin type IV (10%); and no improvement in one case with skin type IV (10%).

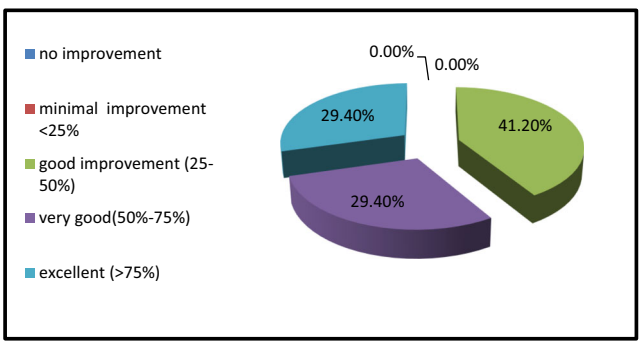


Fig. 1 Overall appearance of area A

Area B results (fractional CO_2 laser)

1—Width of the largest striae

Average of improvement in width of largest striae was 36.76%. More detailed results are postulated in Table 4. The mean score was 1.94. We evaluated the factors that may affect the improvement of the width of the striae and no correlation was found with the age of the patient ($p = 0.339$), disease duration ($p = 0.892$), type of striae ($p = 0.911$), location of the striae ($p = 0.654$), or the skin type. Our results showed very good improvement in two cases with skin type III (33.3%), two cases with skin type IV (20%), and one case with skin type V (100%) and good improvement in three cases with skin type III (50%) and four cases with skin type IV(40%).

Table 4 Percentage of reduction in the width of largest striae in area B

Patient number	Size of largest striae		Reduction in the width of largest striae
	Before treatment	After treatment	
1	1.3 cm	1 cm	20%
2	0.6 cm	0.4 cm	30%
3	1 cm	0.6 cm	40%
4	0.6 cm	0.3 cm	50%
5	1.8 cm	1.1 cm	38%
6	0.5 cm	0.2 cm	60%
7	0.5 cm	0.3 cm	40%
8	0.3 cm	0.3 cm	0%
9	1 cm	0.4 cm	60%
10	1.1 cm	0.5 cm	54%
11	0.5 cm	0.4 cm	20%
12	0.3 cm	0.2 cm	30%
13	0.9 cm	0.7 cm	20%
14	0.9 cm	0.8 cm	10%
15	1.5 cm	0.6 cm	60%
16	0.3 cm	0. 1 cm	60%
17	0.6 cm	0.4 cm	33%

2—Patient satisfaction

The patients' questionnaire revealed good and very good improvement in most patients (five and four respectively), excellent improvement in one patient, and minimal improvement in seven patients. The mean score was 1.94.

3—The blinded physician evaluation

Evaluation of the striae assessed by a blinded physician showed excellent improvement in two patients, very good improvement in eight patients, good improvement in five patients, and minimal improvement in two patients. The mean score was 2.58. There was no correlation between the evaluation results and the patient age ($p = 0.109$), duration of the striae ($p = 0.485$), the type of striae ($p = 0.753$), location of the striae ($p = 0.583$), or the skin type. Our results showed excellent improvement in one case with skin type III (16.7%) and one case with skin type V (100%), very good improvement in two cases with skin type III (33.3%) and three cases with skin type IV (30%), good improvement in three cases with skin type III (50%) and five cases with skin type IV (50%), and minimal improvement in two cases with skin type IV (20%).

4—Improvement in texture

The improvement of texture of the striae was excellent in one patient, very good in three patients, good in six patients, and minimal in seven patients. The mean score was 1.88. An inverse relationship was observed between improvement in texture and the age of the patient ($p = 0.009$) (*correlation coefficient* = 0.612). There was, however, no correlation between improvement in texture and duration of the striae ($p = 0.354$), the type of striae ($p = 0.955$), the location of the striae ($p = 0.585$), or the skin type. Our results showed excellent improvement in one case with skin type III (10%), very good improvement in two cases with skin type IV (20%), and one case with skin type V (100%), good improvement in four cases with skin type III (66.7%) and one case with skin type IV (10%), and minimal improvement in two cases with skin type III (33.3%) and six cases with skin type IV (60%).

5—Overall appearance assessment

The overall improvement of the striae was assessed and revealed excellent improvement in four patients, very good improvement in four patients, good improvement in seven patients, and minimal improvement in two patients (Fig. 2). The mean score was 2.58. There was no correlation between the overall improvement and the age of the patient ($p = 0.271$), duration of the striae ($p = 0.436$), nor the location of the striae ($p = 0.854$). Our results showed excellent improvement in two cases with striae on the abdomen (20%) and two cases with striae on the thighs (40%); very good improvement in one case with striae on the abdomen (10%), two cases with striae on the thighs (40%) and one case on the calves (100%); good improvement in six cases with striae on the abdomen (60%) and one case with striae on the arms (100%); and minimal improvement in one case with striae on the

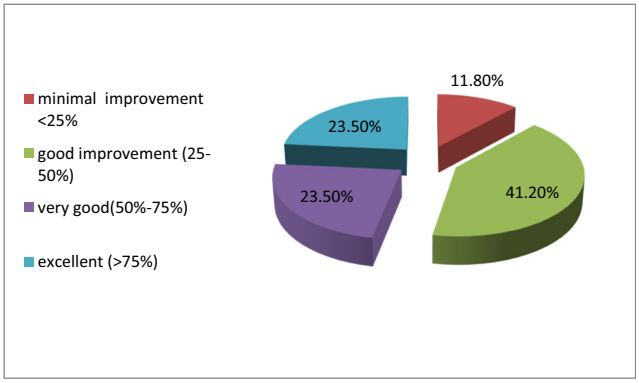


Fig. 2 Overall appearance of area B

abdomen (10%) and one case with striae on the thighs (20%). There was also no correlation between the overall improvement and the skin type. Our results showed excellent improvement in three cases with skin type III (30%) and one case with skin type V (100%); very good improvement in four cases with skin type IV (40%), good improvement in two cases with skin type III (33.3%), and five cases with skin type IV (50%); and minimal improvement in one case with skin type III (16.7%) and one cases with skin type IV (10%).

Correlation between area A and area B results

On comparing between the results of FMR and fractional CO_2 laser, both devices showed good to very good improvement in most patients. The results of the assessment were summarized in (Table 5; Fig. 3).

1—The width of largest striae in area A compared to area B

On comparing the width of largest striae in area A and area B before and after the treatment, area A (FMR) showed more improvement (44.29%) than area B (fractional CO_2 laser) (36.76%). The difference, however, was not statistically significant ($p = 0.381$) (Table 6; Fig. 4).

2—The patient satisfaction in area A compared to area B

On comparing the patient satisfaction in area A and B, patients were more satisfied in area B (fractional CO_2 laser). There was, however, no statistically significant difference between patient satisfaction in both areas ($p = 0.409$).

3—The blinded assessment in area A compared to area B

On comparing the blinded assessment in area A and B, results were better in area A (FMR). There was, however, no statistically significant difference ($p = 0.241$).

4—The texture in area A compared to area B

On comparing the texture in area A and B before and after the treatment, results were better in area B (fractional CO_2 laser). The difference, however, was not statically significant ($p = 0.599$).

5—The overall appearance assessment in area A compared to area B

On comparing overall assessment in area A and B, area A (FMR) showed slightly better improvement. The difference, however, was not statistically significant ($p = 0.716$) (Fig. 5).

6—The unpleasant sequelae (PIH) in area A compared to B

On comparing the sequelae such as PIH in both areas, it was found that PIH developed in nine patients (52.9%) on the area treated with fractional CO_2 laser, whereas none of the areas treated by FMR developed any PIH. This was a statistically significant difference between area A and area B ($p = 0.001$). PIH developed after the first session in some patients and later in others. Six (66.7%) patients from 10 patients with skin type IV developed PIH, two (22.2%) patients from six patients with skin type III developed PIH and also, the only patient with skin type V developed PIH. Six (66.7%) patients from 14 patients with striae albae developed PIH, and all patients with

Table 5 Summary of results of treatment between area A and area B

	Number of patients showing improvement Area A (FMR)					Number of patients showing improvement Area B (fractional CO_2 laser)				
Points of assessment	None	Minimal	Good	Very good	Excellent	None	Minimal	Good	Very good	Excellent
Width of largest striae	0	1	10	5	1	1	4	7	5	0
Patient satisfaction	0	6	9	1	1	0	7	5	4	1
Blinded assessment	0	0	6	5	6	0	2	8	5	2
Texture of striae	0	6	9	1	1	0	7	6	3	1
Overall assessment	0	0	7	5	5	0	2	7	4	4

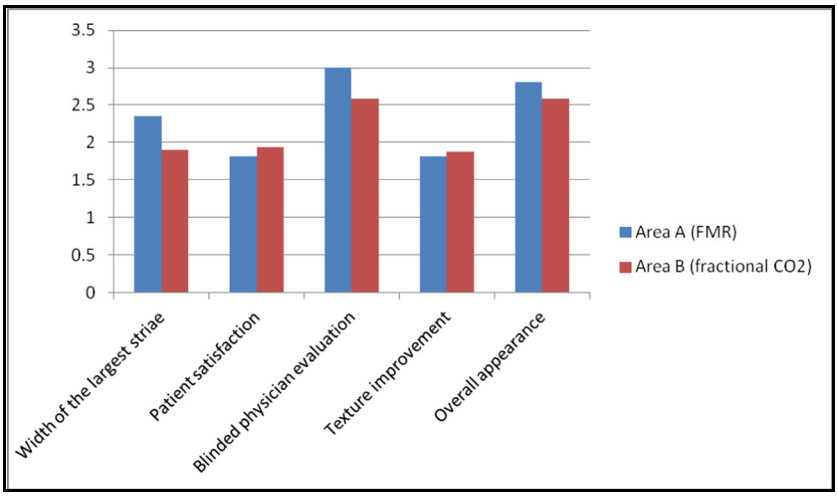


Fig. 3 Comparison between area A and area B

striae rubrae developed PIH. In four of the patients (44.4%), who developed PIH, the cause of striae was pregnancy. In three of the patients (33.3%), who developed PIH, the cause of striae was steroid use. In two of the patients (22.2%), who developed PIH, the cause of striae was weight gain.

Discussion

Striae are a well-recognized, common skin condition that rarely cause a significant medical problem but are often a significant source of distress to those affected. Treatment of SD has always been challenging. Although several treatments have been proposed, no consistent modality is curable. With a relatively high incidence and unsatisfactory treatments, striae remain an important target of research for an optimum consensus of treatment [9].

Fractional CO_2 laser has been used in treatment of SD. With fractional laser, only a fraction of the whole skin is treated in a pixelated pattern while the intervening skin remains intact. Treatment with fractional laser leads to formation of longitudinal micro-thermal zones (MTZs) in the skin which are separated by healthy, untreated skin with an intact epidermis. Fractional CO_2 laser stimulates epidermal turnover and dermal collagen remodeling. It improves texture and appearance of the striae [6].

The FMR device has also been used in the treatment of SD [7]. Its mechanism of action is delivering fractions of energy creating zones of thermal damage in the deep dermal collagen adjacent to unaffected areas. This stimulates wound healing, dermal remodeling and new collagen, elastin, and hyaluronic acid formation in the treated areas [10]. The needles used may be insulated or un-insulated. When using FMR with un-insulated micro-needles, the electrothermal damage is delivered down the whole needle. It is, hence, not truly microfractional because the tissue between the needles is damaged for the whole width and length of the needle. This is different from FMR-insulated micro-needles, where the needle is insulated except for the tip. In that case, no electrothermal damage is delivered to either the epidermis or the insulated area of the needle above the tip [11]. Our aim in this work was to assess and compare the efficacy of FMR and fractional CO_2 laser in treatment of SD. Our present study showed that FMR is an effective and safe treatment for SD. We evaluated improvement according to reduction in width of largest striae and found the average improvement to be 44.29%. We evaluated the factors that may affect this improvement and found no correlation with the age of the patient ($p = 0.713$), disease duration ($p = 0.255$), type of striae ($p = 0.833$), or location of

Table 6 Percentage of improvement in width of largest striae in area A and area B

		Area A (FMR)		Area B (fractional CO2 laser)		*P* value
		Count	%	Count	%	
"Improvement of width of largest striae"	No improvement	0	.0%	1	5.9%	
	Minimal improvement < 25%	1	5.9	4	23.5%	0.381
	Good improvement (25–50%)	10	58.8%	7	41. 2%	
	Very good (50–75%)	5	29.4%			
	Excellent (> 75%)	1	5.9			

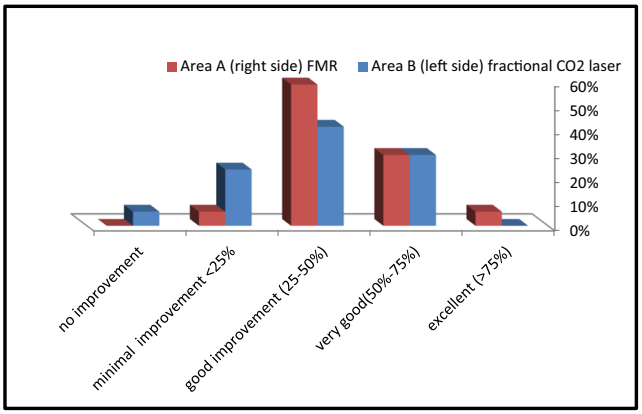
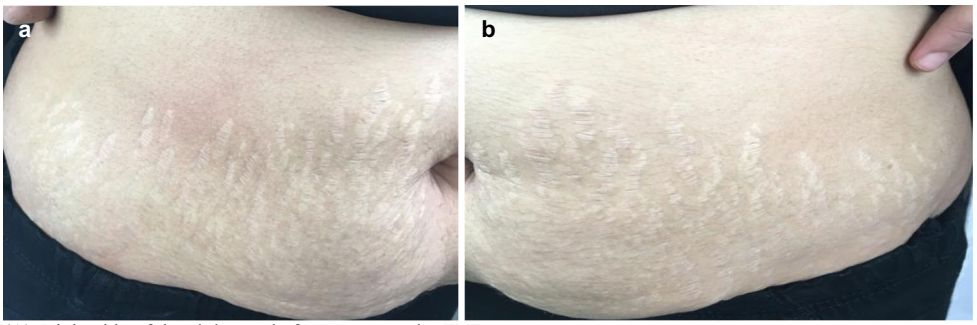


Fig. 4 Comparison of improvement of the width of the largest striae in area A and B

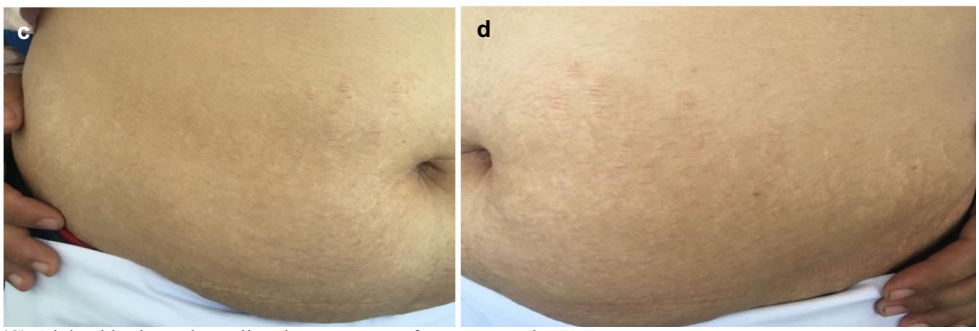
the striae ($p = 0.755$). Patient satisfaction evaluation showed good improvement in most of the cases (52.3%). Upon evaluation of the factors that may affect patient satisfaction, no correlation was found with the age of the patient ($p = 0.929$), disease duration ($p = 0.898$), type of striae ($p = 0.921$), and location of the striae ($p = 0.711$). One blinded physician's assessment results showed that most of the cases had excellent improvement (35.3%). No correlation, however, was found with the patients' age ($p = 0.913$), the duration of the striae ($p = 0.599$), the type of the striae ($p = 0.322$), nor the location of the striae ($p = 0.683$). Improvement in texture evaluation showed good improvement (52.3%) in most cases. There was no correlation with the age of the patient ($p = 0.929$), duration of the striae ($p = 0.898$), type of the striae ($p = 0.877$), and location of the striae ($p = 0.566$). The overall assessment, which was based on clinical examination 1 month after the last session, showed good improvement (41.2%) in most cases. No correlation was found with the age of the patient ($p = 0.917$), duration of the striae ($p = 0.892$), type of the striae ($p = 0.344$), nor location of the striae ($p = 0.688$).

A number of studies using FMR showed results similar to ours. In a study done by Naein and Soghrati [12], the mean surface area of the SD markedly decreased ($p < 0.001$) after treatment by FMR, although only three sessions were done at 4-week intervals for every patient. They used nearly the same parameters we used in our study and in each session; three passes were delivered. They did not mention the type of needles they used which may be insulated or non-insulated (which were used in our study). Also, no correlations were done between improvement in the width of the striae and age of patient, disease duration, nor type of striae. Similar results were also obtained by Ryu et al. [7] who showed moderate improvement in most patients. Improvement was evaluated using a visual analogue scale (range 1–4). The mean clinical score was 1.8. Skin biopsies were taken and revealed epidermal thickening and an increased number of collagen bundles in the treated sites. They only did 3 sessions at 1-month intervals. The parameters they used were 3-mm micro-needle penetrating depth, power level was 7, and 70- to 130-ms pulse time. They did not mention the type of needles they used. Pongsrihadulchai et al. [13] also reported similar results.

Fig. 5 Clinical case



(A) Right side of the abdomen before treatment by FMR
(B) Left side of the abdomen before treatment by fractional CO_2 laser



(C) Right side showed excellent improvement after treatment by FMR
(D) Left side showed excellent improvement after treatment by fractional CO2 laser

They showed improvement in the width and the length of the striae with statistical significance ($p < 0.001$). The number of collagen and elastin bundles significantly increased when compared with the baseline ($p = 0.005$). Moreover, the collagen bundles became thicker and more densely accumulated at the upper dermis than the baseline. The patients received three sessions at 4-week intervals. This device delivered the RF energy through 160 pins per tip, with a maximum energy of 62 mJ per 1 pin. They used 150 × 20 non-insulated needles in this study.

In our study, the fractional CO_2 laser showed to be a safe and effective in the treatment of SD. We evaluated improvement according to reduction in width of the largest striae, and the average improvement was 36.76%. We evaluated the factors that may affect this improvement and found no correlation with the age of the patient ($p = 0.339$), disease duration ($p = 0.892$), type of striae ($p = 0.911$), nor location of the striae ($p = 0.654$). Patient satisfaction evaluation showed minimal improvement in most cases (41.2%). No correlation was found with the age of the patient ($p = 0.855$), disease duration ($p = 0.709$), type of striae ($p = 0.653$), nor location of the striae ($p = 0.822$). One blinded physician's assessment showed good improvement in most cases (47.1%). No correlation was found between the evaluation results and the patients' age ($p = 0.109$), duration of the striae ($p = 0.485$), the type of striae ($p = 0.753$), nor the location of the striae ($p = 0.583$). Improvement in texture showed minimal improvement in most cases (47.1%). An inverse relationship, however, was observed between improvement in texture and the age of patient ($p = 0.009$) (correlation coefficient = 0.612), but there was no correlation between improvement in texture, duration of the striae ($p = 0.354$), type of striae ($p = 0.955$), nor location of the striae ($p = 0.585$). And overall assessment, which was based on clinical examination 1 month after the last session, showed good improvement in most of the cases (41.2%). No correlation was found with the age of the patient ($p = 0.271$), duration of the striae ($p = 0.436$), type of the striae ($p = 0.693$), and location of the striae ($p = 0.854$).

Similar results were obtained by Lee et al. [14], who showed excellent improvement in 23% of patients, very good improvement in 23% of patients, good improvement in 40% of patients, and minimal improvement in 12% patients. All patients were striae alba, treated with a single session using the following parameters: a spot diameter of 1 to 10 mm according to the width of the lesions, a pulse energy of 10 mJ, stacking 2, 300 Hz, and a single pass was done. Similar results were also obtained by El Taieb and Ibrahim [6], who showed moderate improvement in 3 patients (20%) and marked improvement in 17 patients (80%). The mean value of width was reduced from 6.95 to 3.25 1 month after the last treatment with high statistical significance ($p < 0.001$). The mean length was reduced from 13.1 before the treatment to 9.3 as measured 1 month after the treatment with significant improvement ($p < 0.001$). The parameters used were 40 mJ energy and pulse width 4 ms. All the patients received monthly treatment for five sessions. Naein and Soghrati [12] showed that the surface area of the striae significantly decreased ($p < 0.001$). The parameters used were fluence 16 ± 2 J/cm^2, dot cycle 5 ± 2, and pixel pitch 0.8 ± 0.1. They did five sessions for all patients every 4 weeks with two passes during the same session.

Different results, however, were obtained by Khater et al. [15], who showed clinical improvement in only 5 of 10 (50%) of the patients. One patient (10%) results were good, three (30%) were fair, one (10%) were poor, and five (50%) did not show any improvement. This difference in the results may be because the parameters used in their study were not high enough compared to our study. They used pulse energy of 16 mJ, 2 stacks, and 600 ms dwell time, and only a single pass was done.

In our study, we observed PIH in 9 (52.9%) patients treated with fractional CO_2 laser. No PIH was observed on the side treated with FMR. Similar findings were obtained by Yang et al. [9], who found that PIH developed in eight patients (81.8%) after fractional CO_2 laser sessions. They used also high fluence pulse energy of 40~50 mJ and a spot density of 75~100 spots/cm^2. In the study done by Lee et al. [14], no patients developed PIH after fractional CO_2 laser. This may be due to the fact that they did only one session and with lower parameters (pulse energy of 10 mJ, stacking 2, and a single pass).

The comparison between the efficacy of FMR and fractional CO_2 laser in the treatment of SD demonstrated that both technologies were effective. Our results showed better results with FMR, as the average improvement in width of largest SD in area A was 44.29% compared to 36.76% in area B but no statistically significant difference was noted ($p = 0.381$). Patient satisfaction was higher in area B than in area A, but there was no statistically significant difference ($p = 0.409$). On comparing the physician-blinded assessment in area A and B, results were better in area A (RF) but there was no statistically significant difference ($p = 0.241$). On comparing the texture in area A and B before and after the treatment, results were slightly better in area B but the difference was not statistically significant ($p = 0.599$). The improvement in skin texture was significantly inversely related to the patient age ($p = 0.009$). This may be explained by the significantly more inflammation in the epidermis after fractional CO2 denoted by the PIH and the better healing of younger patients. On comparing the overall appearance assessment in area A and B, area A showed slightly better improvement but the difference was not statistically significant ($p = 0.716$). On reviewing the literature, no similar studies were found comparing between the efficacy of FMR and fractional CO_2 laser in treatment of SD. However, some studies evaluated the efficacy of combination therapy of FMR and fractional CO_2 laser in the treatment of SD. Naein and Soghrati [12] compared between the efficacy of FMR

combined with fractional CO_2 laser and FMR alone in the treatment of striae. Five sessions with 4-week intervals for each patient with the following parameters: for (fractional micro-needle radiofrequency + CO_2 laser) laser type: ultra-pulse, 10,600 nm; laser power 16 ± 2 J/cm^2; laser energy 20 mJ; ablation depth 600 μm; dot cycle (duration) 5 ± 2 ms; and pixel pitch 0.8 ± 0.1. In each session, two laser pulses were delivered. And parameters for FMR device were as follows: depth: 3 mm; level 9; and time 110–150 ms. In each session, three laser pulses were delivered. Better results were reported in the FMR + CO_2 group than in the FMR group ($p < 0.00$).

In conclusion, both FMR and fractional CO_2 laser are effective in the treatment of SD (rubrae and albae). Although FMR showed better overall results, the difference was not statistically significant. The incidence of PIH with fractional CO2, however, was significantly higher.

Recommendations Further studies are needed to compare the efficacy of FMR & fractional CO_2 laser with different parameters in the treatment of SD.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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