Comparative Study Between the efficacy of Long-Pulsed Neodymium- YAG Laser and Fractional CO₂ Laser in the Treatment of Striae Distensae

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Abstract

Introduction: Stretch marks, or striae distensae (SD), are the lesions of the dermis caused by its linear atrophy at the sites of stretching. They occur in more than 70% of pregnant women and adolescents as a result of cutaneous stretching. This study aimed at evaluating and comparing the clinical and histological efficacy of the fractional CO₂ laser versus the long pulsed (LP) Nd: YAG laser in the treatment of striae alba.

Methods: Thirty female subjects having bilateral symmetrical stretch marks were managed by the LP Nd: YAG laser on the right side and the fractional CO₂ laser on the left side. The laser treatment course consisted of 3 sessions with an interval of 3 weeks. The patient satisfaction score and the Global Aesthetic Improvement Scale (GAIS) were employed in the study in order to assess the improvement 3 months after therapy. Punch biopsies measuring 4 mm were extracted from one lesion on each side at baseline and after the last treatment session by 3 months to evaluate the thickness of both collagen and epidermis.

Results: Clinical improvement was more significant in the lesions treated by the LP Nd:YAG laser than those treated with the fractional CO₂ laser. The patient satisfaction score and the GAIS were higher with a statistically significant value in the side treated by the LP Nd:YAG laser. Collagen and epidermal thickness increased more in the LP Nd: YAG laser-treated lesions in comparison to their thickness in the fractional CO₂ laser-managed lesions, but this difference did not have a statistical significance.

Conclusion: The clinical efficacy of the LP Nd-YAG laser exceeded that of the fractional CO₂ laser in the treatment of striae alba without severe side effects in spite of the insignificant histological difference between the two lasers.

Keywords: Stretch marks; Striae alba; Long pulsed (LP) Nd-YAG Laser; Fractional CO₂ laser.

Introduction

Striae distensae (SD), commonly named stretch marks, are a type of dermal scarring that arise on the skin as erythematous, violaceous, or hypopigmented linear patterns.¹ Stretch marks associated with pregnancy are called 'striae gravidarum' and occur in more than 70% of pregnant females. The pathogenesis of SD is not well identified and is perhaps multifactorial, but it is clearly due to changes in the structures that give the skin its strength and elasticity.²

Physiological states like fast weight gain, adrenocortical excess, and pregnancy, and pathological states such as long-term use of either systemic or topical steroids, Cushing and Marfan syndromes, as well as genetic alterations in connective tissue with reduced expression of fibronectin and collagen genes in involved tissue, might altogether add to the occurrence of SD.³ Although SD do not result

in any medical problems, they cause psychological stress for many women.⁴

Though numerous options have been tried to treat and improve the clinical appearance of SD, most have yielded suboptimal results.⁵ Such treatments include topical retinoids, microneedling, chemical peeling, radiofrequency, platelet-rich plasma, and ablative and nonablative lasers.⁵ Lasers used for treating stretch marks include diode laser, 308-nm excimer laser, 1064-nm neodymium-doped yttrium aluminum garnet (Nd: YAG) laser, 585-nm pulse dye laser and ablative fractional CO₂ resurfacing laser.⁶

The fractional ablative CO₂ laser was used primarily for treating surgical and acne scars because of its capability of triggering elastin regeneration as well as collagen remodeling. Furthermore, it has been reported that the fractional CO₂ laser induces new collagen formation to

a superior degree than the nonablative lasers.⁷ Several studies in the literature have reported its safety and efficacy in treating SD given the fact that SD is considered a type of a dermal depressed atrophic scar.⁸

The 1064-nm long pulsed (LP) Nd: YAG laser is well recognized for treating vascular lesions and has also exhibited the capability to stimulate the formation of dermal collagen when used to treat facial rhytides.⁹ The combination of collagen induction and vascular selectivity has confirmed to be beneficial in treating immature striae rubra in patients with skin phototypes II–IV.¹⁰

To our knowledge, no previous research works have compared the effects of the fractional CO₂ laser and the LP Nd: YAG laser on the treatment of stretch marks. Thus, the aim of the present study was to assess and compare the clinical and histological effectiveness of the fractional CO₂ laser and the LP Nd: YAG laser in treating striae alba.

Patients and Methods

This study was a prospective intra-patient comparative study. The screening of 70 women having striae alba and Fitzpatrick skin type III–V was performed, leaving only 46 females who fulfilled the inclusion criteria. Two female candidates were dropped after the first treatment session, 13 candidates were dropped after the second treatment session, and only one candidate was dropped after the third treatment session. As a result, in this study, we had 30 female patients who completed their treatment sessions. The sites of SD included the flanks, breasts and thighs. The duration of SD lesions varied from 1 to 20 years. The age of the patients was in the range of 18–35 years. Exclusion criteria included patients with striae rubra, pregnant and lactating women, patients treated by topical or systemic steroids, retinoids, oral contraceptive pills, hormone replacement therapy, anticoagulants and immunomodulators. In addition, females having systemic disorders such as diabetes, hypertension, Cushing syndrome, goitre, asthma, connective tissue disorders, bleeding or coagulation disorders and immunocompromised states were not included in the study. Also, patients having liability to develop keloids or post-inflammatory hyperpigmentation (PIH) were excluded from the study. The random recruitment of the patients was done at the dermatology clinic, National Research Centre (NRC), Giza, Egypt.

Stretch marks were assessed to detect their sites and their types. The assessment of the extent of the lesions was established by the measurement of both width and length of SD. The evaluation of the treated SD was done before the treatment, at the beginning of each session and 3 months after the third session.

Management of Striae With Fractional CO₂ and Nd:YAG Lasers

Two bilateral symmetrical striae alba were chosen in

every patient (left and right). The Fractional CO₂ laser was applied to SD on the left side using the Pixel CO₂ resurfacing system, China, at the energy of 60 mJ, the scanning area of 5 mm × 5 mm and the pulse duration of 2 ms. One pass of fractional CO₂ was applied to the SD lesions. On the other hand, the LP Nd: YAG laser was applied to striae on the right side using the Fotona XP Dynamis laser machine, Slovenia. To determine the suitable parameters of the LP Nd:YAG laser in order to be used in this study, we tested several parameters on volunteers before recruiting our patients or starting this research. On using low parameters, the response was not satisfactory for both the patients and the physician. On the other hand, using high parameters resulted in pain and a higher incidence of side effects, especially erythema and edema that lasted for several days, followed by hyperpigmentation as the case in the Egyptian patients' skin type. Accordingly, the parameters used were 80 J/cm² fluence, 4-mm spot size and 15-ms pulse duration, which are relatively near to those used by Elsaie et al.¹¹ The 4-mm spot size was enough to completely cover the width of all lesions included in the study. Two laser passes of LP Nd:YAG were applied to the SD lesions. Three laser sessions were done in all patients with a 3-week interval. Cooling by cold air was done during the session in order to diminish any discomfort. In addition, goggles and wet gauze pads were used to protect the eyes. All subjects were requested to mention any side effects during the course of laser treatment, such as redness, swelling, itching, pain, pigmentation or crustation. An antibiotic was applied topically 3 times daily for 3 consecutive days after the treatment session.

Histological Evaluation of Striae Alba

Punch biopsies measuring 4 mm were extracted from SD lesions from seven candidates chosen randomly. In each candidate, two biopsies were taken at baseline (one from the side that was treated by the fractional CO₂ laser and one from the side that was treated by the LP Nd:YAG laser). Another two biopsies were extracted from the same lesions after the last session by 3 months.

All biopsies first emerged in 10% buffered formalin, and then they were processed into paraffin blocks and finally cut into paraffin sections. All sections were stained with Hematoxylin and eosin (H&E) for evaluating the lesions histologically and Masson trichrome (MT) stain for examining collagen fibers. A blinded dermatopathologist assessed all skin biopsies histologically at baseline and after the treatment by the Fractional CO₂ and LP Nd: YAG lasers.

Examination of Collagen Fibers

The morphometric evaluation of collagen fibers was carried out at the Pathology Department, NRC, using the Leica Qwin 500 Image Analyzer (LEICA Imaging Systems

Ltd, Cambridge, England) which is composed of the Leica DM-LB microscope and the JVC color video camera attached to a computer system Leica Q 500IW. Random quantitative morphometric analysis was performed in 5 high-power fields.

Quantitative morphometric analysis of all slides stained by Masson Trichrome was done using $\times 10$ objective lens. The color detect software was employed in order to determine the collagen amount. The recording of the mean area of the collagen fibers in Masson trichrome stained sections was carried out by a binary image on a real-time image from the microscope that was visualized on the video monitor. Statistical analysis of the mean area percent given by the image analyzer was performed, and the ANOVA test was used to assess significant variations in the findings between the groups.

Photographic evaluation

Photos of SD were taken before starting the treatment, at the beginning of each session and 3 months after the last treatment session using the same camera (Panasonic L28 camera, 8.1 megapixel, China). The photographic assessment was carried out by two blinded dermatology specialists in accordance with the width and length of SD at baseline and after the laser treatment course.

Global Aesthetic Improvement Scale

The Global Aesthetic Improvement Scale (GAIS) was employed in order to assess the degree of the improvement of SD 3 months after the third treatment session, in which 1 = very much improved, 2 = much improved, 3 = Improved, 4 = No change and 5 = Worse.¹¹

Patient Satisfaction Score

The patients uttered their satisfaction as follows: 1 = very satisfied, 2 = satisfied, 3 = neither satisfied nor unsatisfied, 4 = unsatisfied and 5 = very unsatisfied.¹¹

Statistical Investigation

Analysis of the data was done by IBM® SPSS® (SPSS Inc., IBM Corporation, NY, USA) Statistics version 26 for Windows. Categorical records were explored as percentages (%) and frequencies (n), and they underwent analysis by Fisher exact test. The quantitative data were presented for normality using the Shapiro-Wilk and Kolmogorov-Smirnov tests. Analysis of parametric data was done by the paired-samples *t* test, whereas analysis of nonparametric data was done by the Wilcoxon signed rank test. For all tests, the significance value was set at $P \leq 0.05$.

Results

30 women whose age ranged from 19 to 35 years with mean $\pm$ standard deviation (SD) of 28.3 ± 4.8 years were included in the current study, and they had striae alba. The

lesions duration was in the range of 4-20 years and most of the patients (56.7%) had their SD for 6-10 years. The reasons for stretch marks were either increasing weight in 27 (90.0%) patients or pregnancy in 3 (10%) patients. The sites of the lesions varied: 8 (26.7%) female candidates had SD on the knees, 5 (16.7%) on the arms, 5 (16.7%) on the legs, 3 (10.0%) on the buttocks, 2 (6.7%) on the shoulders, 2 (6.7%) on the thighs, 2 (6.7%) on the back, 2 (6.7%) on the flanks, and only 1 (3.3%) on the breast.

The majority of the subjects (80.0%) included in the study had a family history of stretch marks. Nineteen (63.3%) subjects had skin type III, 8 (26.7%) subjects had skin type IV and 3 (10.0%) subjects had skin type V. The BMI index for all patients varied from 22 to 30 with mean $\pm$ SD of 25.7 ± 2.5 .

Length and Width of Striae Alba Before and After the Treatment

Fractional CO₂ Laser

The length and width of lesions treated with the fractional CO₂ laser improved significantly after a treatment course of 3 laser sessions. The length of the lesions ranged from 1 to 4 mm before the treatment and reached 0 to 3 mm after the treatment with mean $\pm$ SD of 2.0 ± 1.0 and 1.2 ± 1.0 mm respectively ($P = 0.011$). However, the width of the lesions before the treatment ranged from 1 to 3 mm and diminished to 0 to 3 mm after the treatment with mean $\pm$ SD of 1.7 ± 0.7 and 1.0 ± 0.8 mm respectively ($P = 0.009$) (Table 1, Figures 1 and 2).

Long Pulsed Nd: YAG Laser

The length and width of the stretch marks also significantly improved after a treatment course of 3 laser sessions using the LP Nd:YAG laser as the length of SD was in the range of 1 to 4 mm before the treatment and was 0-3 mm after the treatment with mean $\pm$ SD of 2.0 ± 0.9 mm and 0.6 ± 0.8 mm respectively ($P = 0.011$). However, the width of SD lesions before the treatment varied from 1 to 3 mm and reached 0-2 mm after the treatment with mean $\pm$ SD 1.4 ± 0.5 mm and 0.5 ± 0.5 mm respectively ($P = 0.009$) (Table 1, Figures 1 and 2).

The comparison of the two laser treatments revealed that the lesions treated by the LP Nd:YAG laser showed a more significant improvement regarding the length and width of SD than the Fractional CO₂ laser-treated lesions ($P = 0.009$ and $P = 0.011$ versus $P = 0.147$ and $P = 1$, respectively) (Table 2, Figures 1 and 2).

Global Aesthetic Improvement Scale Score and Patient Satisfaction Score

The GAIS values after the treatment were significantly higher in the case of LP Nd: YAG laser treatment compared to fractional CO₂ laser treatment, as 7 (23.3%) lesions demonstrated very much improvement and 12 (40%) lesions demonstrated much improvement versus 16

(53.3%) and 8 (26.7%) lesions that showed improvement and no change respectively after fractional CO₂ laser treatment ($P<0.001$). Moreover, 3 months after therapy, the cases expressed higher satisfaction with LP Nd: YAG laser management than fractional CO₂ laser management ($P<0.001$).

Examination of Adverse Events

The subjects had more adverse events with the fractional CO₂ laser in comparison to the LP Nd-YAG laser ($P<0.001$). Twenty-five (83.3%) cases had erythema in fractional CO₂ laser-managed areas compared to 4 (13.3%) cases after the therapy by the LP Nd-YAG laser. In addition, permanent PIH occurred more with the fractional CO₂ laser, as it occurred in 5 (16.7%) cases compared to 0% of the cases after the LP Nd-YAG laser treatment. No patients complained of infections, burns or scars.

Histological Examination

Thickness of Epidermis

There was an increase in the thickness of the epidermis after the two laser treatments, LP Nd: YAG laser and fractional CO₂ laser treatments, but without any statistically significant value (mean $\pm$ SD for the LP Nd: YAG laser at baseline: 130.0 ± 22.4 μ m versus after the therapy: 183.8 ± 10.4 μ m, $P=0.182$; mean $\pm$ SD for the fractional CO₂ laser at baseline: 128.2 ± 19.8 μ m and after the therapy: 187.5 ± 15.9 μ m, $P=0.1$) (Table 3, Figures 3 and 4).

Thickness of Collagen

After the treatment, there was an increase in the mean area percent of collagen with both LP Nd: YAG laser and fractional CO₂ laser managements; however, it did not have a statistical significance (mean $\pm$ SD before the

Table 1: Length and Width of Striae Distensae Treated by the Fractional CO₂ Laser and the LP Nd:YAG Laser Before and After the Treatment

Laser	Parameter	Before Treatment	After Treatment	P Value
Fractional CO ₂	Width Mean $\pm$ SD	1.7 $\pm$ 0.7	1.0 $\pm$ 0.8	<0.001*
	Median [Range]	2.00 [1.00-3.00]	0.00 [0.00-3.00]	
	Length	2.0 $\pm$ 1.0	1.2 $\pm$ 1.0	<0.001*
	Median [Range]	2.00 [1.00-4.00]	1.00 [0.00-3.00]	
Nd: YAG	Width Mean $\pm$ SD	1.4 $\pm$ 0.5	0.5 $\pm$ 0.5	<0.001*
	Median [Range]	1.00 [1.00-3.00]	0.00 [0.00-2.00]	
	Length	2.0 $\pm$ 0.9	0.6 $\pm$ 0.8	<0.001*
	Median [Range]	2.00 [1.00-4.00]	0.25 [0.00-3.00]	

*Significant (P value ≤ 0.05).

Table 2: Comparison Between the Effect of the Fractional CO₂ Laser and the LP Nd: YAG Laser on the Width and Length of Striae Distensae

Time	Parameter	Fractional CO ₂ Laser	Nd: YAG Laser	P value
Before treatment	Width	1.73 $\pm$ 0.74	1.47 $\pm$ 0.57	0.147 ^{ns}
	Length	2.07 $\pm$ 0.90	2.07 $\pm$ 1.01	1 ^{ns}
After treatment	Width	1.00 $\pm$ 0.83	0.50 $\pm$ 0.57	0.009*
	Length	1.25 $\pm$ 1.06	0.65 $\pm$ 0.83	0.011*

* Significant (P value ≤ 0.05); ns: non-significant (P value >0.05).

Table 3. Epidermal and Collagen Thickness in Striae Distensae Treated by Each of the Fractional CO₂ Laser and the Nd:YAG Laser Before and After the Treatment.

Laser	Parameter	Before Treatment	After Treatment	P Value
Fractional CO ₂	Epidermis	128.2 $\pm$ 19.8	187.5 $\pm$ 15.9	0.105 ^{ns}
	Median [Range]	129.4 [77.8-177.5]	190.0 [160.1-210.2]	
	Collagen	1.2 $\pm$ 0.8	4.2 $\pm$ 1.0	0.116 ^{ns}
	Median [Range]	1.7 [0.1-1.7]	2.7 [2.2-7.6]	
Nd: YAG	Epidermis	130.0 $\pm$ 22.4	183.8 $\pm$ 10.4	0.182 ^{ns}
	Median [Range]	129.6 [87.9-172.7]	188.4 [171.9-191.2]	
	Collagen	0.8 $\pm$ 0.6	3.5 $\pm$ 1.4	0.179 ^{ns}
	Median [Range]	0.4 [0.4-1.5]	4.3 [0.7-5.3]	

ns: non-significant (P value >0.05).

Figure 1. (A) The right thigh of a 26-year-old female patient before Nd: YAG treatment, (B) After three Nd: YAG treatment sessions, (C) The left thigh of the same patient before fractional CO₂ laser treatment (D) After three fractional CO₂ laser sessions.

treatment for the LP Nd: YAG laser: $0.8 \pm 0.6 \mu\text{m}$ and after the therapy: $3.5 \pm 1.4 \mu\text{m}$, $P = 0.179$; mean $\pm$ SD before the treatment for the fractional CO₂ laser: $1.2 \pm 0.8 \mu\text{m}$ and after the therapy: $4.2 \pm 1.0 \mu\text{m}$, $P = 0.116$ ns).

On comparing the two treatment options as regards the thickness of both epidermis and collagen, there was a more increase in their thickness in lesions managed by the LP Nd: YAG laser than those treated by the fractional CO₂ laser. But the difference was not statistically significant ($P = 0.8$ for collagen thickness and 0.9 for epidermal thickness).

Discussion

The aim of the present study was the clinical and histopathological evaluation and comparison of the efficacy of the LP Nd: YAG laser and the fractional CO₂ laser in treating stretch marks. Thus, 30 women complaining of SD with an age varying from 19 to 35 years were included in the study.

In the current work, all lesions treated with either the LP Nd: YAG laser or the fractional CO₂ laser showed clinical improvement as the length and width of stretch

marks diminished after the therapy, but the histological improvement in both treated lesions did not reach a significant level after the treatment. Moreover, the comparison of both laser options demonstrated more statistically significant clinical improvement in SD treated with the LP Nd: YAG laser than those managed by the fractional CO₂ laser. In addition, the patient satisfaction score and the GAIS score were significantly higher in SD managed by the LP Nd: YAG laser.

The results of the current work are in agreement with many reports in the literature that confirmed the effectiveness of fractional photothermolysis in the treatment of SD. Yang et al¹² reported the efficacy of the CO₂ laser in treating stretch marks. In addition, Lee et al¹³ applied the ablative fractional CO₂ laser to SD in 27 cases. The lesions were managed in one session using a deep FX mode at the energy of 10 mJ and a density of 2 (10% coverage). The study concluded that the fractional CO₂ laser could be efficient in the treatment of stretch marks. Also, Cho et al¹⁴ treated SD with the fractional CO₂ laser and showed a significant improvement of lesions after therapy.

The conclusion of the study done by Elsaie et al¹¹ is in agreement with the conclusion of this study regarding the safety and effectiveness of the LP Nd: YAG laser in the treatment of stretch marks. Additionally, Zaleski-Larsen et al¹⁵ treated 20 patients having striae alba with the LP

Figure 2. (A) The right arm of a 29-year-old female patient before Nd: YAG treatment, (B) After three Nd: YAG treatment sessions, (C) The left arm of the same patient before fractional CO₂ laser treatment (D) After three fractional CO₂ laser sessions.

Figure 3. (A) Skin biopsy of untreated striae on thighs and (B) biopsy of the same site of striae treated by the long-pulsed Nd: YAG laser 3 months after the last session. Note the increased epidermal thickness and the thickness of dermal collagen (hematoxylin and eosin, $\times 40$) (C) Skin biopsy of untreated striae on thighs and (D) biopsy of the same site of striae treated by the long-pulsed ND YAG laser at the end of the study (3 months after the last session). Note the increased collagen density (Masson trichrome).

Figure 4. (A) Skin biopsy of untreated striae on thighs and (B) biopsy of the same site of striae treated by the fractional CO₂ laser 3 months after the last session. Note the increased epidermal thickness and the thickness of dermal collagen (hematoxylin and eosin, $\times 40$) (C) Skin biopsy of untreated striae on thighs and (D) biopsy of the same site of striae treated by the fractional CO₂ laser at the end of the study (3 months after the last session). Note the increased collagen density (Masson trichrome).

Nd: YAG laser, and there was an improvement in the lesions.

In the present work, although a significant clinical improvement was observed in lesions treated by the two laser types, there was no significant histological improvement regarding both the collagen and epidermal thickness after the last laser session by 3 months. The epidermal and collagen thicknesses were higher in SD managed by the LP Nd: YAG laser than those managed by the fractional CO₂ laser, but the difference between the two lasers was statistically insignificant.

Disagreeing with this study conclusion was the research work carried out by Güngör et al¹⁶ who compared the 2940 nm Er: YAG laser and the LP Nd: YAG laser in 22 candidates suffering from SD. The SD on the two sides of the body were randomly subjected to the two types of lasers, and 3 laser sessions were performed in all cases at one-week intervals. Striae rubra showed a moderate clinical improvement, whereas striae alba showed a poor clinical improvement to therapy on both sides. Histological improvement was demonstrated after the therapy on both sides despite the poor clinical response noted in the two sides.

The previous result can be explained in accordance with Aust et al,¹⁷ who reported that the deposition of collagen and elastic fibers reached its significant level at 6 months after treatment, and the thickness of the epidermis increased significantly 1 year after treatment, which was not done in this study as there was only a 3-month follow-up period which is considered short.

The LP Nd: YAG laser has a strong affinity with vascular structures and at the same time causes an increase in dermal collagen, leading to the improvement of immature SD. As the dilated venules and perivascular infiltrate of lymphocytes present in SD lesions are the desirable targets of the Nd: YAG laser due to their content of oxyhemoglobin, the LP Nd: YAG laser causes deposition of a good energy packet in the dermal tissue.¹⁸

When the LP Nd: YAG laser is absorbed by the dermal vessels, an increase in the temperature around these vessels is produced, causing thermal damage sufficient to trigger wound healing and collagen remodeling.⁵ Moreover, this laser stimulates the formation of new collagen fibers augmenting the improvement of stretch marks.¹⁹

In the current work, adverse events were noticed more with the fractional CO₂ laser than the LP Nd: YAG laser as 83.3% of the cases complained of erythema in the fractional CO₂ laser-treated lesions in comparison to 13.3% of the cases after the management with the LP Nd: YAG laser. Moreover, permanent PIH was noticed more in the fractional CO₂ laser-treated areas in 16.7% of the patients compared to 0% of the patients after the therapy with the LP Nd: YAG laser. No patients suffered from infections, burns or scars.

The research work performed by Güngör et al¹⁶ was in

line with our findings as it showed that long-term mild redness and PIH were observed in 6 out of 20 candidates managed by the Er: YAG laser, while there were no side effects on the LP Nd: YAG laser managed areas.

Conclusion

To conclude, this study reported that the LP Nd: YAG laser is more effective in treating stretch marks than the fractional CO₂ laser without serious adverse effects in spite of the insignificant difference between the two lasers histologically. The results of the present work concerning the adverse events of the two laser types encourage the use of the LP Nd: YAG laser in treating striae because the adverse effects were found to be higher with the fractional CO₂ laser versus the LP Nd: YAG laser. It is recommended to perform other studies on a large scale of cases in order to support or oppose the conclusions of this research paper. Also, a long-term follow-up is required in future studies in order to have sufficient time for collagen fibers to be deposited in a significant amount.

Ethical Considerations

The approval of the research protocol was performed by the committee of research ethics, NRC, Giza, Egypt.

Conflict of Interests

The authors declare that they have no conflict of interest.

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