The Efficacy of Variable Intense-Pulsed Light (VPL) Treatment of Striae Distensae: a new phototherapeutic approach

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Background. Stretch marks or striae distensae are cosmetically displeasing to many patients. Although stretch marks are very common, satisfactory therapeutic intervention has been disappointing. Objective. To assess gross and microscopical changes that occur in striae distensae treated with variable pulsed light (VPL). Patients& Methods. The study included twenty patients with striae. Ten sessions of double-pass VPL were performed in each of the patients once weekly. Skin biopsies, before and after treatment, were taken. Data concerning the morphological featured included measuring of the length and width of each of the treated striae. For statistical analysis paired "t" test was used. Results. Patients showed clinical and microscopical improvement. The "t" test showed statistically significant differences in the post treatment length and width of treated striae (P<0.01). Microscopically, post-treatment epidermal and dermal thickness demonstrated statistically significant differences (P<0.05, P<0.01 respectively). Conclusion. Striae distensae improved clinically and microscopically after VPL treatment. It seems to be a promising therapeutic option for this common problem.

Stretch marks or striae distensae are cosmetically displeasing to many patients. Clinically, in early stages, stretch marks are flat linear bands with a faint pink color, which develop a violaceous hue as they enlarge both in length and width (striae rubra). Over time, these bands become increasingly atrophic, depressed, and attain a white color. They are referred to as mature striae (striae alba). Stretch marks occur in areas of mechanical stress as the abdomen, buttocks and/or the thighs. These lesions are reported in multiple clinical settings such as, adolescent growth spurts, pregnancy, potent topical or systemic corticosteroid therapy, obesity, and weight lifting (1).

The precise etiology of striae is not well understood. Part of the difficulty in determining its etiology is the variability in the clinical situations in which it arises. Histopathological findings vary depending on the age of the lesions. Early lesions show superficial and deep perivascular infiltrate of lymphocytes and sometimes eosinophils, as well as widely dilated venules and edema in the upper part of the dermis. Elastolysis, mast cell degranulation and activated macrophages have also been described in early striae (2). Fully developed lesions show scant infiltrate of lymphocytes around venules. Bundles of collagen in the upper third of the reticular dermis are thinned and aligned parallel to the skin surface. Elastic fibers appear to be increased in number and packed together as a consequence of loss of collagen bundles. In late stages, these findings are exaggerated with a thin epidermis devoid of rete ridges. Loss of elastic tissue accompanies loss of collagen; resulting in a decrease in the thickness of the dermis. Therefore, it has been suggested that the extracellular matrix, which provides strength and resiliency, is altered or damaged in striae (1).

Although stretch marks are very common, satisfactory therapeutic intervention has been disappointing. The treatment of striae distensae or stretch marks has included many modalities, with variable success regarding their therapeutic outcome (3, 4). The use of topical
agents has been tried including tretinoin, ascorbic acid, and glycolic acid. Topical tretinoin 0.1% improved both the color and length/width measurements in a controlled study. However, qualitative and quantitative analysis of elastic and collagen tissue staining did not reveal significant differences between tretinoin-treated and vehicle-treated groups (3). In another study optical profilometry was used to measure topographical changes in striae after treatment with either 0.5% tretinoin cream, 10% L-ascorbic acid, or 20% glycolic acid. Unfortunately, improvement was only reported in early striae and little or no effects were seen in mature ones (4).

Later, treatment modalities were focused on methods that remove the epidermis and cause a dermal wound with subsequent dermal collagen remodeling. These methods include, besides chemical peels, dermabrasion, and ablative lasers, including, pulsed CO2 and Er:YAG lasers. Such methods commonly lead to postoperative complications such as oozing, bleeding, infections, and the occasional incidence of undesirable postinflammatory pigmenitary changes (5-7).

Non-ablative laser therapy has recently gained popularity as a therapeutic alternative for stretch marks, as well as for other different forms of scars (8). The flash lamp-pumped pulsed dye laser (PDL; 585 nm) has been the most commonly reported laser used for the treatment of striae (9,10).

Intense-pulsed light (IPL), is a noncoherent filtered flashlamp with a very broadband spectrum (515-1200 nm). It emits a visible polychromatic pulsed light of high intensity. Non-laser light can be delivered with a variety of designated wavelengths. Filters are used to include or exclude particular wavelengths. IPL is used in photoepilation (11), lentigens (12), vascular malformations (13), poikiloderma of Civatte (14) and facial aging (15). The facial photodamage was clinically and microscopically improved by IPL. When higher filters are chosen shorter wavelengths which may damage the epidermis without adequate dermal penetration to promote collagen remodeling are blocked. The longer deeper penetrating wavelengths are non-specifically absorbed in the human dermis. These wavelengths cause a non-specific dermal wound, resulting in non-ablative dermal remodeling with subsequent replacement of elastosis by a more orderly neo-collagen (12). These results have prompted the trial of IPL in the treatment of striae distensae. The newest generation of IPL systems deliver the selected wavelength in micro-pulses, that can be adjusted regarding their duration and the delay that separate them one from the other (in milliseconds ms); hence, these systems deliver Variable-Pulsed Light (VPL). Initial studies (16,17) suggest that VPL can substantially improve facial rhytides by its presumed effects on dermal collagen; however, no studies evaluated its effects on stretch marks.

Aim of the study
To evaluate the efficacy of VPL treatment of striae distensae. The study herein reports the clinical and histologic results of nonablative, variable-pulsed light treatment on striae distensae.

PATIENTS & METHODS

Patients
Twenty patients (4 males and 16 females), were included in the study. Treatment striae were randomly selected from every patient. Control (untreated) striae from each patient were also selected for control. Patients ranged in age between 18 and 45 years of age (average of 28 years). The duration of treated striae ranged between 6 months to 20 years (average of 9 years and 4 months). The cause of striae in the study group varied from fast growth in adolescent spurts (13 patients), pregnancy (3 patients), weight training (3 patients), and weight loss (1 patient).

Treated striae were located on the abdomen/groin (9 patients), axilla/anterior shoulder (6 patients), and buttocks/upper thighs (5 patients). Nine of the treated striae were pink to red in color, and eleven were white in color. Every patient signed an informed consent before starting treatment.

Exclusion Criteria:
Patients were excluded because of prior treatment of striae six months before the study, concomitant systemic steroids, Cushing's disease, history of collagen or elastic tissue
disorders, history of keloids, and/or female patients known to be pregnant.

A total of sixty striae (three striae/patient) have been selected for VPL treatment. Their lengths ranged between 17-35 cm (average 26 cm), and their widths ranged between 1-5 mm (average 3 mm). Clinical improvement of striae was assessed, both by the patient and the physician, immediately prior to each VPL session, as well as, two weeks after the last treatment. These data were classified in a scale by crosses: 0 = no improvement, + = mild, ++ = moderate, +++ = good, ++++ = very good.

Methods

The ENERGIST-Ultra, Energist Ltd, U.K., was adjusted to deliver pulsed light of 590 nm wavelength through a standard spot size of 50x10 mm. All the patients were started on a fluence of 30 J/cm². This starting dose was then increased by 20% irradiation dose increments in subsequent sessions, according to the tolerance of the patient, judged by the absence of pain sensation; and the response of the skin, noted by the absence of burning erythema at the end of each treatment. The ENERGIST-Ultra represents the second generation of pulsed-light treatment technology, which delivers variable pulsed light (VPL). Each shot of VPL comprises a sequence of four rapid micro-pulses. These micro-pulses are of variable durations (2, 2.5, 3 and 4 milliseconds (ms), and are separated by a delay of 20 ms.

The operator and the patients' eyes were protected by specific eye goggles provided with the VPL-Ultra machine. The treatment areas were painted with refrigerated cooling gel (4°C), and the window was placed right on it. The shots were made one after the other until the whole area has been treated. A light redness was considered as absolutely normal. In case of strong redness, immediate application of physiological saline together with fluence reduction was carried out. Local anaesthesia, in any form, was not used; as the subjective pain sensation is a crucial monitoring sign during irradiation fluence adjustment.

Ten sessions of double-pass VPL were carried out for each patient, once a week. Patients were photographed immediately before the first session, and two weeks after the tenth session. Two 4 mm punch biopsies were taken, both of the same stretch mark, one before treatment and one more two weeks after the last session. The obtained biopsies were stained by H&E. The degree of atrophy of the epidermis was measured on a scale to indicate if such finding was: 0 = non-existent, + = mild, ++ = moderate, +++ = good, ++++ = very good.

RESULTS

The results are divided into two sections: clinical and histopathological assessments. The ten sessions of VPL resulted in reductions in the lengths and widths of treated striae in comparison to the untreated ones in the same patient (control). Two weeks following the tenth VPL session, the mean length decreased from 26.33 ± 1.09 cm to 16.00 ± 0.9 cm. Applying the "t" test for statistical analysis, the reduction was found to be significant (p<0.01). Similarly, post-treatment measurement of the mean of the widest portion of the treated striae resulted in a significant reduction from 3.93 ± 0.23 mm to 2.05 ± 0.15 mm (p<0.01).

Comparison of the clinical overall appearance of striae pre and post treatment, as reported separately by the patients and the treating physician, showed post-treatment improvement, which was moderate in eight patients (40%), good in four patients (20%), and very good in eight patients (40%) (Fig. 1).

![Fig. 1. VPL-induced improvement in the clinical overall appearance of striae distensae](image)
Histopathologically, the epidermis showed pretreatment atrophy in all cases. This atrophy was considered severe in ten patients (50%), moderate in six patients (30%), and mild in four patients (20%). Post-treatment atrophy changed to mild in 5 patients (25%), moderate in 8 patients (40%), and only 3 patients (15%) remained with severe atrophy. No atrophy was noted in 4 patients (20%) (Fig. 2). The mean epidermal thickness increased, in post-treatment assessment, from 0.17±0.03 mm to 0.5±0.05 mm (p<0.05).

Fig. 2. Percentage of epidermal atrophy in striae distensae before and after VPL treatment.

The mean dermal thickness increased from 2±0.3 mm to 3.3±0.4 mm in pre- and post-treatment measurements respectively (p<0.01). As regards elastosis and edema, pre-treatment evaluation showed severe degrees in 60% of the patients, moderate in 20%, and mild in 20%. Post-treatment assessment revealed mild degrees in 60% of patients, moderate in 20%, and severe in 20% (Fig. 3).

Fig. 3. Percentage of dermal elastosis and oedema before and after VPL treatment.

Telangiectasias did not show any change, being severe in 40% of patients, moderate in 40%, and mild in 20% in both pre- and post-treatment evaluations. Pre-treatment perivascular inflammation was moderate in 60% of patients, mild in 20%, and absent in 20%. Two weeks after the last VPL session, inflammation was moderate in 20% of patients, mild in 50%, and absent in 30% (Fig. 4).

Fig. 4. The percentage of perivascular inflammation before and after VPL treatment.

The collagen fibers revealed moderate damage in 40% of patients and severe damage in 60% before treatment commencement. Post-treatment, the damage was mild in 50% of patients and moderate in the other 50% (Fig. 5, 6).

None of the patients reported any of the side-effects that they were told to observe including, blistering, pain, longstanding erythema, pigmentation and/or scarring.

Fig. 5. Pre-treatment biopsy showing epidermal atrophy. The dermis shows thin, faint and fragmented collagen bundles (H&E, x4).
DISCUSSION

Striae distensae remain a frequently encountered, difficult-to-treat cosmetic problem. Topical therapies yield variable therapeutic results, and surgical options carry an increased risk for further scar development (3, 4). Non-ablative laser treatment represents the newest approach to initiate and enhance dermal collagen remodeling. After laser irradiation of the skin, thermal injury is localized to the papillary and upper reticular dermis, while the epidermis is concomitantly protected by surface cooling. Various non-ablative laser systems proved to improve different clinical situations characterized by atrophy and/or scarring. Induction of dermal collagen without epidermal damage was first demonstrated using a 585-nm flashlamp-pumped pulsed dye laser (PDL) for hypertrophic scars (18, 19), and in the treatment of facial rhytides (9, 20). Regarding the therapeutic outcome of PDL in striae distensae, reports were conflicting. Some studies (10, 21) reported improvements of this cosmetic problem whether in the clinical appearance and/or the histologic findings. Whereas, others (22, 23) found no differences in the condition after PDL treatment. Subsequently, the 1320-nm Nd: YAG and 1450-nm diode offered another safe and effective noninvasive technique. Modest long-term clinical improvement of atrophic scars has been reported (24, 25).

Lately, treatment of striae with IPL has been suggested as a therapeutic modality that is aimed at improving the appearance and histology of stretch marks. The exact mechanism of action of IPL in the treatment of striae is unknown but effects on fibroblasts and mast cells leading to collagen remodeling have been speculated (26). These speculations are evidenced by the effectiveness of IPL in photorejuvenation (27, 28), treatment of facial rhytides (29), and poikiloderma of Civatte (30).

In this study, all patients showed various degrees of satisfactory changes regarding the appearance of their treated striae. The improvement was good and very good in most of them. All clinical features assessed showed significant improvement, including the lengths, widths, as well as, the overall clinical appearance of striae, in comparison to control (untreated striae of the same patient). Differences between the length and width of pre and post-treatment striae were statistically significant (p<0.01).

All parameters evaluated at microscopy, except telangiectasia, showed variable but satisfactory degrees of improvement. Despite the fact that most of histologic findings are subjectively evaluated, they still correlate with the objectively assessed clinical signs of improvement, including the pre and post-treatment measurement of the lengths and widths of striae. Furthermore, these microscopic parameters provide the cellular explanation for the clinical improvement including, improvement in the epidermal atrophy, dermal elastosis, edema, inflammation, and quality of the collagen fibers. The lack of improvement regarding telangiectasia could be caused by that the wavelength used in this study (590 nm) differs from that needed to achieve a satisfactory effect on dilated blood vessels (550-570 nm). The epidermal thickness was increased on average from 0.17 to 0.5 mm. Such difference was considered statistically significant (p <0.05). The dermal thickness showed the most important improvement at the end of treatment.
encountered cosmetic problem. 

In none of the patients studied were neither "no improvement" nor adverse reactions that lead to inconvenience, lack of compliance and/or discontinuation of treatment.

In conclusion, VPL is a low-risk, well-tolerated procedure that can potentially affect collagen remodeling. It seems to be a promising alternative for treatment of striae distensae. The satisfactory clinical and histologic outcome data point out that the non-ablative Variable Pulsed Light technology is an option to be considered in this frequently encountered cosmetic problem.

REFERENCES