Review Article

Striae Distensae Treatment Review and Update

Abstract

Striae distansae (SD) or stretch marks are very common, asymptomatic, skin condition frequently seen among females between 5 to 50 years of ages. It often causes cosmetic morbidity and psychological distress, particularly in women and in certain professions where physical appearances have significant importance. Of late, with the increasing emphasis on cosmetic management and awareness, patients approach dermatologists for stretch marks treatment. However, despite several advances, no fully effective treatment has emerged. Unfortunately, there is paucity of the strong evidence in the literature for the effective treatment of striae. A literature search using the terms 'striae distansae (SD or stretch marks' was carried out in the PubMed, Google Scholar and Medline databases. Only articles related to the treatment were considered and analysed for their data. Commonly cited treatments include topical treatments like tretinoin, glycolic acid, ascorbic acid and various lasers including (like) carbon dioxide, Er:YAG, diode, Q-switched Nd:YAG, pulse dye and excimer laser. Other devices like radiofrequency, phototherapy and therapies like platelet rich plasma, chemical peeling, microdermabrasion, needling, carboxytherapy and galvanopuncture have also been used with variable success. This article reviews all currently accepted modalities and their effectiveness in the treatment of stretch marks.

Keywords: *Lasers, striae, treatment*

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Introduction

Striae distensae (SD) commonly known as stretch marks are visible linear scars which develop in areas of dermal damage as a result of excessive stretching of the skin. They are twice as common in females and are reported in the age group of 5–50 years.[1]

Striae are extremely common and often cause cosmetic morbidity and psychological distress, particularly in women and certain professions. Of late, with the increasing emphasis on cosmetic management and awareness; patients approach dermatologists for striae treatment. However, despite several advances, no fully effective treatment has emerged.

This article will evaluate the existing treatments and their efficacy and provide a concise review of available therapeutic modalities for SD.

Methods of search: A through search of the literature using the words 'striae distensae', striae rubra, striae alba and stretch marks was carried out in the PubMed, Google Scholar and Medline databases. Articles which focused on the treatment of SD were considered and analysed critically.

Etiopathogenesis

Striae generally develope 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, obese or weight loss.[2]

They are also seen in pathological conditions with hypercortisolism like Cushing's syndrome[3] and genetic disorders such as Marfan syndrome.[4] SD sometimes may occur as a side effect related to drugs such as local or systemic corticosteroid therapy[3,5] and anti-retroviral protease inhibitors (indinavir).[6]

The origin of SD is thus multifactorial and exact etiopathogenesis of SD still remains controversial. Primary pathology lays in altered dermal connective tissue framework involving components of extracellular matrix (ECM) namely fibrillin, elastin, fibronectin and collagen.[7,8]

In the initial stages, elastic fibres undergo elastolysis along with degranulation of mast cells.[9] Affected tissue may also show

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low expression of collagen and fibronectin genes or high proportion of rigid cross-linked collagen, which makes the connective tissue prone to stress rupture.[1]

Other factors like genetic predisposition, mechanical stress, hormones especially corticosteroids (both topical and systemic) also play an important role in causation.[1,3]

On histopathology, in initial stage (i.e., striae rubra (SR), the epidermis is almost normal and dermis is oedematous with perivascular lymphocytic cuffing suggestive of inflammation. As ageing of lesion occurs, i.e. striae alba (SA) epidermis becomes thin, atrophic with blunting of rete ridges and absence of skin appendages.[10]

Clinical features

Early lesions of SD are smooth, raised, irritable and erythematous to bluish in colour, known as SR. As the lesion ages, it flattens, becomes pale and irregular with finely wrinkled surface known as SA; which is usually permanent.[1]

Clinically SD appear as multiple, symmetric, well defined, irregularly linear, red to pale coloured (depending upon the stage) atrophic scars which follows the lines of cleavage and lies parallel to the skin surface.

The pubertal growth spurt induced SD are commonly seen after thelarche. They are present over thighs, buttocks and breasts in girls. In boys, they often develop over lumbosacral region and outer aspect of the thighs. Stretch marks of pregnancy, also known as striae gravidarum (SG);[11] are commonly seen over abdomen, breast and thighs in third trimester. SG lesions are more common in young primigavida and are associated with higher weight gain in pregnancy, large for gestational age babies and increased risk of traumatic vaginal delivery.[12]

Overall striae are generally benign in nature; rarely the bigger lesions may ulcerate or rupture if traumatised.[1]

As explained earlier, multiple pathological changes occur in the dermal connective tissue components as lesions of SD progress from SR to SA stage. They are reflected macroscopically as altered texture, strength and colour of the skin.

The dermal collagen bundles get thinned out with altered orientation of fibres.

Diagnosis of striae is often clinical and straight forward without any need of specific investigation.

Treatment

Striae, while otherwise being harmless, are frequent cause of cosmetic concern or disfigurement leading to distress in the affected individuals especially females. With increasing preference for outdoor activities such as gym and swimming; apparels which reveal part of the riff, midriff or thighs, in the modern women, treatment of striae has become a necessity in many patients.

In adolescents, SD associated with pubertal growth spurt becomes less conspicuous with time and has excellent prognosis as compared to other SD. Other SD, like SG tends to improve to some extent after delivery.[1] Even corticosteroid-induced striae may disappear or become inconspicuous after withdrawal of offending steroid. Hence counselling is an important part of initial management in all cases.

Multiple treatment options have been reported with varying success, from numerous topicals to lasers and energy based devices. However, most available publications are small studies, case reports and very few case-controlled double blind trials. Only a few of these are proven and have evidence, whereas many others are hyped by product manufacturers.

In view of this, it is very important to understand the basis of different therapeutic options and to choose the right modality and ensure proper counselling to the patients to optimise treatment outcome.

Box 1 enumerates the targets of different therapeutic modalities used in SD.[13,14]

General measures for prevention of striae

Development of stretch marks may be prevented by avoidance of brisk weight gain or loss; particularly in high-risk groups, e.g., adolescents, athletes and pregnant women.

Dietary modifications and exercise plan were thought to be important for reduction of SD in earlier days. A study conducted by Schwingel *et al.* has failed to demonstrate effect of any weight loss programme diet and any type of exercise on SD.[15]

Topical treatments

The various topical therapeutic agents used for SD are enlisted in Table 1. Tretinoin and retinoic acid have been found to be useful in several studies.[14,16] In early SD, it is believed to act by stimulation of fibroblasts leading to increase tissue collagen levels. Studies have found it to be

Box 1: Treatment targets of different therapies used in striae distensae

Induction of dermal collagen production and fibroblastic activity (to improve tissue strength)
Reduction of lesional vascularity (especially in SR)
Reduction in wrinkling and roughness of skin (to improve texture)
Increase in pigmentation (in SA)
Increase in elasticity and blood perfusion
Improvement in cell proliferation
Increased skin hydration and
Anti-inflammatory properties

effective in SR also, though transient erythema and scaling were most common side effects.[16,17]

Hyaluronic acid is also found to be effective in SD as it increases collagen production.[18] Other agents used with varying success are trofolastin (Centella asiatica), silicone, glycolic acid, ascorbic acid, alphasria, cocoa butter, olive oil, almond oil, chamomile, coconut oil and bio-oil.[14]

In one study, pirfenidone which is a small synthetic non-peptide having immuno-modulatory as well as anti-inflammatory properties has also been used. It can also modulate collagenase, fibroblastic activity and cytokines in the wound healing process thus found to be effective in SD.[19]

In spite of multiple topical therapies being available for treatment of SD, there are limited numbers of evidence-based scientific studies documenting the efficacy of these agents. The reported efficacy is modest and the drugs need to be used for prolonged periods of time. Therefore, efficacy of topicals in prevention and treatment of SD is questionable.

Table 1: Topicals agents used for striae distensae

Topical agent used	Mechanism of action
Tretinoin or retinoic acid	Increase tissue collagen I levels through fibroblastic stimulation
Hyaluronic acid	Increase tensile resistance to mechanical forces
Trofolastin (Centella asiatica)	Stimulation of fibroblasts and antagonist to glucocorticoid effect
Silicone	Skin hydration
Acid peels - glycolic acid, trichloroaceticacid (TCA)	Proliferation of fibroblast and stimulate collagen production by fibroblasts
Ascorbic acid	Improved collagen production
Alphasria	Increasing volume to oppose mechanical atrophy
Cocoa butter	Mositurisation
Oils - olive oil, almond oil, coconut oil, bio oil	Action by massage and cutaneous hydration
Pirfenidone	Immunomodulatory, anti-inflammatory, promote collagenase, fibroblastic activity

Procedural therapies

In the recent years, there has been a dramatic increase in minimally invasive non-surgical skin rejuvenation procedures and technologies which offer minimal downtime leading to increased patient compliance. The basic principle on which these therapies are based is induction of controlled inflammation in dermis which results in stimulation of neocollagenesis by recruitment of fibroblast. To be effective in SD, in addition to neocollagenesis, these modalities should also reduce erythema in SR and improve pigmentation in SA. Different procedural therapies used for SD are enlisted in Table 2.

Table 2: Procedural therapies used for striae distensae

Type of procedure
Lasers
Ablative fractional CO_2 10,600 nm
Non-ablative fractional Er:YAG 1540 nm
Non-ablative 1450 nm diode laser
1064 nm Nd:YAG laser
Flash-pumped 585 nm pulsed dye laser
Cu bromide laser
308 nm excimer laser
Light-based therapies
Intense pulsed light
UVB/UVA1 combined therapy and targeted phototherapy
Infrared light
Radiofrequency (or ablative/non-ablative)
Non-fractional
Fractional
Microneedle radiofrequency (MNRF)
Galvanopuncture
Carboxytherapy
Microdermabrasion
Platelet rich plasma (PRP)
Microneedling therapy or percutaneous collagen induction therapy
Chemical peeling

Lasers

Lasers are the light energy based devices which deliver coherent, cohesive and monochromatic light energy to the skin by acting on specific tissue chromophore. The lasers target different chromophores such as water, haemoglobin and melanin and thus improve overall appearance of SD by increasing collagen production, decreasing vascularity (especially in SR) and by increasing melanin pigmentation.[13,20] Both ablative and non-ablative lasers have been tried with varying success in striae management.

Ablative Lasers

Ablative lasers of wavelength more than 1000 nm are readily absorbed by tissue water, results in cell vaporisation, tissue heating and remodelling.[21] The commonly used ablative lasers for SD are CO_2 (10,600 nm) and Er:YAG (2940 nm).[20]

However, ablative lasers are associated with severe erythema, post-procedure pigmentation and prolonged downtime.

In an attempt to combat these shortcomings, the concept of fractional photothermolysis was introduced. In this, the laser beam creates non-contiguous areas of thermal damage having controlled width, depth and density with sparing of adjacent epidermis termed 'microthermal tissue zones'.[22] Within these areas, localised epidermal necrosis occurs alongside collagen denaturation. Ultimately, the necrotic debris is expelled and neocollagenesis occurs. All this leads to rapid dermal collagen remodelling with sparing of

intermittent epidermis, ultimately leading to improvement in these atrophic dermal scars.[23] These devices are thus associated with minimal downtime and are dealt with more detail below.

Fractional CO_2 10,064 nm (Fr CO_2)

This laser stimulates fibroblast activity, induces dermal tissue remodelling and thus has been successfully used for laser resurfacing of SD.[24] The clinical improvement was also reflected histopathologically as increase in thickness of epidermis and dermis as well as higher immunoreactivity of procollagen type 1.[25] However, multiple sessions were needed.

The use of this laser is associated with erythema, post-treatment pain, crust formation and pigmentary dyschromia which may be a cause of concern in the darker skin types IV and VI.[26,27] Shin *et al.* in his study proposed the positive effect of succinylated atelocollagen with fractional resurfacing CO_2 laser on SD.[28] In another study, monthly fractional CO_2 laser sessions were compared with topical therapy regimen comprising 10% glycolic acid + 0.05% tretinoin cream at every night. The former was found to reduce the mean surface area of SD more effectively as compared to the topical therapy.[29] Fractional CO_2 laser was more effective in reduction of mature SD than in SR.[27] Treatment outcome of fractional CO_2 laser was found to be augmented when used in combination with pulsed dye laser (PDL).[30] In a study comparing ablative laser (fractional CO_2) with non-ablative lasers (1540 Er glass laser) in SD, both were found equally effective, but the latter was more patient friendly and better tolerated.[26]

Fractional Er:YAG laser

Variable square pulse Er:YAG laser has been used for resurfacing of the SD. Wanitphakdeedecha *et al.* has shown efficacy of lower fluence in volumetric reduction of striae.[31] In another comparative study with variable square pulse Er:YAG and Nd:YAG laser investigators have refuted use of either lasers in management of SA.[32] In comparative study of PDL and fractional Er:YAG laser, both were found to be equally effective, though Er:YAG laser was preferred by patients.[33] The laser has also been found effective in ethnic skin especially skin type IV–VI in terms of efficient fractional non-ablative photothermolysis as well as minimal side effect profile. On an average 6–8 sittings at 4 weekly intervals are required to obtain sustainable improvement in dimensions, texture and pigmentation of SD.

Non-ablative Lasers

Erbium glass (Er glass 1540 nm) laser

Erbium glass laser has also been used for fractional photothermolysis. Generally, repetitive treatments (4–6 sessions) are required at 4–6 weeks interval.[23,34,35] The laser (1550 nm) has shown to reduce dimensions of SD with improved elasticity, colour and skin texture; when used by multiple investigators in different striae like SG,[36] breast striae post-augmentation surgery[37] and steroid-induced striae.[38] Stotland *et al.* has reported overall improvement in dimensions of SD independent of age, gender and skin phototype with the use of 1550 nm, erbium-doped fibre laser; but lesser improvement in dyschromia and texture of striae.[39] Most common adverse events were transient pain, post-treatment erythema, oedema and dyschromia.[40] In another study by Wang *et al.* two different wavelengths 1540 and 1410 nm of lasers were compared; both were found efficient in SD reduction without any significant difference between the two.[41] Tretti and Lavagno has used a different frequency 1565 nm (Resur FX) laser in stretch marks which demonstrated improved pigmentation, volume and textural appearance of SD.[42]

Pulsed dye laser

Initial stages of SR are marked by erythema due to presence of dilated blood vessels and the haemoglobin in these microvasculature acts as a chromophore for PDL, making it a good treatment candidate for SD management. McDaniel and colleagues[43] have used PDL at different energy densities for SD and found improvement in appearance of the striae with higher energy. They concluded it was due to increased dermal elastin and collagen production. In other studies there was limited improvement noted in SA as compared to SR, the overall improvement was more in colour. Study by Nehal *et al.*[44] had noticed only mild subjective improvement in texture of mature SD with the use of PDL but it failed to show the same changes histopathologically. In darker skin types (IV–VI) melanin also competes with haemoglobin as a target for PDL, thus the use of this laser increases the risk of pigmentation post-therapy.[45] There are multiple comparative studies performed with PDL versus intense pulsed light (IPL),[46] fractional CO_2[27] and Er:YAG[33] lasers; which concluded that it is better than IPL but not superior to fractional ablative lasers. In one study when fractional CO_2 and PDL were used together, it was found that the combination of two lasers is superior to the single modality.[30]

308 nm Excimer laser

Excimer laser has a wavelength in the narrow-band ultraviolet B (NBUVB) light spectrum. As compared to other lasers, excimer laser specifically acts by increasing pigmentation of SA and hence are thought to be useful in striae atrophicans.[47] A study conducted by Goldberg *et al.* on the use of excimer laser for SA found cosmetically significant pigmentation of SA with repetitive sessions.[48] In a further comparative study (2005), the same author has investigated the use of UVB light therapy and the excimer laser in SD and found repigmentation of SD with both the light as well as laser. On histopathology and electron microscopic study, excimer laser was found to cause hypertrophy and hyperplasia of melanocytes leading to

increase melanin pigmentation without any improvement in dermal atrophic scarring.[49] Other studies have also confirmed this finding in SA as well as in hypo-pigmented scars. However, in study conducted by Ostovari *et al.* use of excimer laser showed very weak results along with splaying of the pigment to surrounding normal skin as a major side effect.[50] All the reported changes are short term and not permanent in nature, and hence multiple maintenance treatments are necessary.[49,51]

Nd:YAG 1064 nm

The neodymium-doped yttrium aluminium garnet has affinity for all the chromphores relevant to SD, viz. Hb, water and melanin. Goldman *et al.* have used it successfully for SR.[52] In another study by Elsaie with the use of two different fluences, investigators reported significant improvement in SA at higher energy of 100 J/cm^2, while SR responded better with 75 J/cm^2 (four sessions).[53] An Egyptian study by El-Ramly *et al.* failed to show any statistically significant clinical improvement in SD after four sittings of Nd:YAG laser.[54]

Diode laser

The 1450-nm diode laser has been shown to increase dermal collagen but it has been reported only once in the literature for the management of SD. In a trial by Tay, three laser sessions with increasing energy failed to show any improvements in SD but there were high rates of adverse events like pigmentary dyschromia and erythema noted.[55]

Copper-Bromide Laser

Copper-bromide laser of wavelength 577 nm is more selective for haemoglobin than PDL and thus was also tried for SD management. Longo *et al.*[56] have used it with fluence of 4–8 J/cm^2 in 15 patients of striae and noted moderate improvement in the lesions but the results were inconsistent. They observed transudation, crusting and scabbing as adverse effects.

Even though the lasers are thought to have role in the SD, body's normal healing process also goes hand in hand with it, which might be contributing to the results of the lasers.[57]

Summary of findings of laser

Although a variety of lasers have been used in SD, results are inconsistent. Fractional ablative and non-ablative lasers perhaps have shown the maximum beneficial outcome.

Radiofrequency

The non-ablative and fractional microneedle radiofrequency (MNRF) devices have been recently used for tightening of the skin with significant efficacy and safety profile. Higher-energy fluences generated by radiofrequency (RF) current by coupling method are delivered to the dermis and subcutaneous tissue without causing damage to the epidermis. This transmitted electrical energy upon reacting with the skin's impedance is converted to homogenously distribute thermal energy, which in turn leads to stimulation of fibroblasts with contraction and denaturation of fibrillar collagen structure. All these changes promote neocollagenosis, neoelastogenesis and changes in ECM.[58] All types of RF devices like monopolar,[59] bipolar,[60] tripolar[61] and multipolar[58] have been successfully used in treatment of SD. A study conducted by Montesi *et al.*, has shown that multiple sessions of bipolar RF are highly effective in SD management showing improvement on clinical, histopathology and immunohistochemistry.[60] Sometimes with higher fluences, erythematous rashes, ecchymosis or occasional blistering are observed. Average number of sittings required in RF is 3–6, performed at 4 weekly intervals. Investigators have used this technology in conjunction with other modalities like PDL,[59] autologous PRP,[62] pulsed magnetic fields,[63] infrared (IR) light therapy[64] as well as topical like retinoic acid[65] and found it to be more efficacious than RF alone in management of SD. The fractional method of delivering heat energy to the tissue has also been used in RF devices for better penetration of thermal energy to the target area with safety. Pongsrihadulchai *et al.* have found statistically significant reduction in dimensions and total surface area of SD with nano-fractional RF.[66] These changes were reflected histopathologically by increase in average mean number of collagen and elastin bundles. A fractional ablative micro-plasma RF roller device (by Alma lasers, Israel) for SD was used by Mishra *et al.* in five patients; the study concluded that there was improvement in the appearance of abdomen striae with this newer device.[67]

Platelet rich plasma

Platelet rich plasma (PRP) is a concentrated solution of plasma containing various growth factors and protein, injected intra dermally and acts by augmenting dermal elasticity by stimulation of ECM and inducing synthesis of new collagen. It has been used alone as well as in combination with RF,[62,68] carboxytherapy,[69] ultrasonography[68] and found to have synergistic effect in the treatment of SD. In a split comparative study of PRP versus carboxytherapy done once a month in 20 patients of SA by Hodeib *et al.*[69] both were found effective; with carboxytherapy being superior to PRP. Gamil *et al.*[70] in a comparative study of PRP versus 0.1% tretinoin cream found it to be more effective than tretinoin for SA. However, this is a recent modality and the results need to be confirmed in larger studies.

Microneedling therapy or percutaneous collagen induction therapy

In this minimally invasive method, small needles are used to create micro channels extending to the papillary dermis. This induced inflammation stimulates dermal wound healing

by increasing collagen and elastin synthesis.[71] Aust *et al.*[72] and Park *et al.*[73] have independently used this therapy and reported marked improvements in appearance and texture of SD. Khater[74] *et al.* compared microneedling with fractional CO_2 laser, while Nasser *et al.*[75] used microneedling versus microdermabrasion (MDA) with sonophoresis; both studies found microneedling/percutaneous collagen induction therapy more effective than the other two. Averages three sessions of microneedling treatment at 4 weekly intervals are needed.

Microdermabrasion

The procedure of micro resurfacing uses aluminium oxide crystals which causes mechanical ablation of damaged skin leading to inflammatory cascade. Even with a single treatment session there is an elevation of transcription factors, cytokines [tumour necrosis factor-α (TNF-α), interleukin-β (IL-β)], matrix metalloproteinases (MMPs)-1,3,8 and increased type 1 procollagen formation.[76] A study done by Abdel-Latif *et al.*[77] showed good-to-excellent response in 20 subjects of SR with monthly sessions of MDA for 5 months. The histochemical analysis showed upregulation of type I procollagen mRNA. Mahuzier[78] states that 10–20 sessions of MDA done at monthly interval lead to epidermal thickening as well as more collagen and elastic fibres in the dermis. The procedure is said to be having no efficacy in hypodermic rupture and it may cause post-inflammatory pigmentary changes as an adverse effect. A comparative study of MDA versus topical tretinoin in early SD by Hexsel *et al.*[79] showed both modalities to be equally efficacious. However, MDA is associated with lesser side effects and better patient compliance.

Intense pulsed light

IPL is a type of non-laser visible light-based device which uses high intensity, non-coherent, filtered flash lamp, with a broadband frequency spectrum of around 500–1200 nm. Studies investigating use of IPL 2–4 weeks apart from five sessions in SD have found significantly increased amide1 and beta sheets along with dermal collagen on histopathology and synchrotron IR microspectroscopy.[80,81] In a comparative study by Mausin *et al.*[82] on two different IPL wavelengths, 590 nm was found to be more effective in reducing erythema and dimensions of SD than 695 nm. However, in comparative studies of IPL versus lasers like fractional CO_2[83] and PDL[46,84] the lasers proved to be superior.

Miscellaneous Light Based Therapies (other than Lasers) for SD

1. UVB (296–315 nm) and UVA1 (360, 370 nm)

A combined UVB and UVA1 wavelength emitting high-intensity light device model with wavelength peaks at 313, 360 and 420 nm was used in SD by Sadick *et al.*[85]

In this study greater than 51% improvement in SA pigmentation was reported after weekly (maximum 10 weeks) phototherapy sessions in all nine study participants. Transient hyperpigmentation of striae was seen in almost half the subjects as an adverse event.[85] On biopsy it failed to show any effect on collagen remodelling, thus limiting its efficacy only for repigmentation of SA.

2. IR light

Thermal energy from IR light is known to cause collagen remodelling and neocollagenesis effects. Trelles *et al.*[86] in his study used IR device to deliver high fluences with high frequency stacked pulses in 10 patients and observed objective improvement in SD did not match visual observations where both physician and patients did not appreciate much clinical benefit.

Chemical peeling

Applications of chemical agents are thought to induce inflammatory response, with subsequent neocollagenosis. The most commonly used agents are trichloroacetic acid, retinoic acid and glycolic acid (GCA).[87,88] Post-inflammatory pigmentary changes and mild irritation are the most common adverse events. Chemical peeling is a cost effective option for treating wider surface area of SD.

Galvanopuncture

In this therapy low level direct micro current is applied to the body with the help of needles to reduce the oxidative injury with subsequent collagen production. Its use in SA was investigated by Bitencourt[89] *et al.* which demonstrated substantial clinical improvements in 32 SD patients after 10 sessions. Ferreira *et al.*[90] has compared galvanopuncture versus dermabrasion; he found both treatments showed improvement in SD but the difference was statistically insignificant.

Carboxytherapy

In this procedure, CO_2 gas is injected subcutaneously at the depth of 5–6 mm in striae, at weekly interval for 3–12 sessions (depending upon the age of striae). This stimulates blood circulation and increases the release of oxygen by means of oxyhaemoglobin. It also activates the synthesis of collagenase, elastin and hyaluronic acid by stimulation of fibroblast function.[91]

Study performed by Podgórna *et al.*[92] demonstrated increase skin elasticity, decrease in SD dimensions and improved aesthetic appearance on cutometric assessment post carboxytherapy. The therapy is associated with moderate pain or discomfort and haematoma formation. However, this modality is controversial and cannot be therefore recommended as a routine treatment.

Practical approach

The above review suggests that while multiple modalities have been documented to be of use, no single treatment is fully satisfactory [Table 3 and Box 2]. The studies are

Table 3a: Different therapies used for striae distensae

Type of modality used in study	Type of study	Machine specifications	Frequency and total no of sittings	Results and remarks	Level of evidence
Fractional ablative CO2 laser[25]	Retrospective cohort study	10,600 nm at 10 mJ/MTZ	Single session Retrospectively reviewed	Almost 60% of patients showed ≥50% clinical improvement in SA Most of the patients were very satisfied A/E - PIH, pruritus, crusting, oozing, erythema	4
Fractional non-ablative Er glass laser[31]	RCT	1550-nm Er:YAG	1-2 sessions with 4 week intervals	Decrease erythema index, melanin index of the treated SD lesions Skin elasticity was partially normalised with increase in epidermal thickness, collagen and elastic fibre A/E- mild, transient pain and hyperpigmentation	2
1550 nm non-ablative fractional Er glass laser[33]	Case series	Moderately high-energy sessions of 1550 nm	5 sessions at 4 weeks interval	Dimensions of both SA and SR were decreased at 1 month and 1 year after treatment in comparison to before	4
Fractional non-ablative Er glass laser[34]	Prospective cohort study	1550 nm at 80-100 mJ/MTZ	4-8 sessions at 4-week intervals	Mean clinical improvement of~80% after an average of 6-7 sessions Mean patient satisfaction score of 8.2/10 A/E - PIH	4
Fractional non-ablative Er glass laser[35]	Cross-sectional study	1540 nm at 70 mJ/MTZ	3-6 sessions at 1-month interval	50% of patients showed clinical improvement after 3 sessions and remaining 50% showed after 4-6 sessions A/E - erythema, oedema	4
Fractional non-ablative Er glass laser[36]	RCT	1550 nm at 12-18 J/cm^2	6 sessions with 2-3 week intervals Untreated site acted as controls	63% patients had almost 50% improvement Improvement in striae dimensions≤50% improvement was observed in texture and colour of the striae A/E - erythema, oedema, blistering	1
Fractional non-ablative Er glass laser[38]	RCT	Abdomen divided into 2 parts treated with 1540 nm at 50 J/cm^2 vs 1410 nm at 30 J/cm^2	6 treatments at 3-6-week interval	All patients demonstrated clinical improvement with histopathology showing increased epidermal thickness, dermal thickness and collagen and elastin density 28% of 1410-nm treated and 33% of 1540-nm treated groups had good or excellent improvements; 71.4% and 28.6% of patients were very satisfied and moderately satisfied, respectively No significant differences between lasers A/E - 1540-nm laser - pain and 1410-nm laser - PIH, pruritus	2
PDL[41]	RCT	585 nm Four treatment protocols (fluence): 1=10 mm, 2.5 J/cm^2; 2=10 mm; 3 J/cm^2, 3=7 mm, 2 J/cm^2; 4=7 mm, 4 J/cm^2 untreated striae in same patient acted as controls	Single session	Improved aesthetic appearance and skin shadowing with all protocols Best results observed with higher fluence, i.e., 10-mm spot size+3 J/cm^2 A/E - purpura, erythema, hyper-hypopigmentation	2

Contd...

Table 3a: Contd...

Type of modality used in study	Type of study	Machine specifications	Frequency and total no of sittings	Results and remarks	Level of evidence
PDL[43]	RCT	585 nm at 3 J/cm^2	Two treatments 6 weeks apart Untreated striae as controls	No significant differences in striae area Colour improvement in SR but not in SA A/E - PIH	2
308 nm excimer laser[46]	RCT	308 nm at 150-900 J/cm^2	Up to 15 sessions	Almost 100% patients achieved darkening and improved appearance of striae	2
XeClexcimer laser[49]	RCT	308 nm	Up to 10 sessions with weekly intervals	80% of patients showed very poor results, without any satisfaction	2
Long-pulsed Nd:YAG laser[50]	Comparative RCT	Striae divided into 3 sections and treated with 1064 nm at 75 J/cm^2 vs 100 J/cm^2 vs control 5 mm spot size and 15 ms pulse duration	4 treatments at 3-week interval	Histopathological and clinical improvement in length and width of striae was seen SA showed better response to 100 J/cm^2 and SR responded better with 75 J/cm^2	2
Long-pulsed Nd:YAG laser[52]	Comparative RCT	1064 nm Nd:YAG laser	4 treatments at 4-week interval	Some clinical and histopathological improvement in SD, but it was not statistically significant	2
1450 nm diode[55]	RCT	1450 nm at 4, 8 and 12 J/cm^2	Three sessions with 6-week intervals	Patients failed to show any improvement A/E - erythema, PIH	I
Tripollar RF[59]	Case control	40-50 W	Six sessions with weekly intervals	Improvement of 25-50% and 51-75% in 38.2% and 11.8% of patients, respectively Patients were slightly satisfied, satisfied and very satisfied (12%, 23% and 65% of patients, respectively No significant differences in striae surface smoothness A/E - occasional pinching, sensation during treatment	4
Nano-fractional RF[66]	Case control	-	3 sessions 4 week interval	The total surface area and the width and the length of striae alba significantly decreased from the baseline Average mean number of collagen and elastin bundles was significantly increased A/E - PIH	3
Ablative fractional microplasma RF[67]	Case control	-	Four sessions every 2 weeks	Mean severity score improved by 20% Mean score from patient assessment was 2.4 (≥50%) (good to very good) A/E -erythema, oedema	4
PCT[72]	Case control	Disk microneedle therapy system (DTS)	3 sessions with 4-week intervals	Marked to excellent improvement in 43.8% with minimal-to-moderate improvement in remaining patients	4

Contd...

Table 3a: Contd...

Type of modality used in study	Type of study	Machine specifications	Frequency and total no of sittings	Results and remarks	Level of evidence
Microdermabrasion[76]	RCT		5 sessions at weekly intervals Other half of body acted as control	Good to excellent (i.e ≥50%) improvement in 50% and mild-to-moderate improvement in the rest Greater improvement in SR Increased type 1 procollagen at mRNA levels in treated striae A/E - PIH, erythema	2
IPL[80]	Case control	535, 550 and 580 nm at 25-35 J/cm^2	Five sessions with 3-4 week interval	Increased collagen, amide1 and beta sheet expression after IPL treatment A/E=stinging sensation	4
IPL[81]	RCT	650 nm at 13-15.5 J/cm^2 vs 590 nm at 13-14.5 J/cm^2	Five sessions with 2-week intervals Different wavelengths used on opposite sides of body	Significant reductions in length and width with both treatments Significant reduction in erythema with 590-nm wavelength along with superior patient Satisfaction scores A/E=erythema, pain, burning, PIH (all more common with 590-nm wavelength)	2
UVB/UVA1 light therapy[85]	RCT	UVB: 296-315 nm 1 UVA: 360-370 nm at 45-400 mJ/cm^2	Biweekly treatments for a maximum of 10 treatments	After final treatment, 5 patients had 100% pigmented striae (hyperpigmented), 3 had 76-100%, and 1 had 51-75% improvement After 12 weeks, 2 patients had 51-75% improvement, 3 had 26-50% improvement and 4 had 0-25% improvement Increase in elastic fibre to collagen ratio in 1 patient A/E -erythema, PIH	2
TCA-based easy peel solution 1 post peel cream[88]	Case control	TCA: 50%	Up to 8 treatments monthly	Almost all had a 60-75% improvement with reduced depth of striae	4

Box 2: Level of evidence study design

1 Randomised, controlled trial, systematic review with meta-analysis
2 Non-randomised, controlled trial, prospective, comparative cohort trial
3 Case-control study, retrospective cohort study
4 Case series cross-sectional study
5 Expert opinion case reports
(Quality rating scheme modified from the Oxford centre for evidence-based medicine for ratings of individual studies)

small with lower evidence levels and hence there are no standard guidelines available for management. From the evidence presented, it would appear that fractional laser and fractional MNRF should be the first line of management, but cost of these treatments and the large areas usually involved in stretch marks would be limiting factors. In such cases, peels or derma rollers with PRP may be a cheaper alternative.

Treatment of SD needs to be tailored to the emotional needs of the person, area of involvement and occupation. It should be made clear during counselling that as of now, none of the treatments can provide complete clearance and multiple sessions are always needed. The efforts should be to use topical therapies in combination with procedural modalities. The authors have made an effort to show these principles in the approach for management in below flow charts [Figure 1a and b].

Conclusion

To offer an effective treatment of SD it is important to perform a complete evaluation of a patient including taking proper history, assessing type of SD and skin type of patient. Even in a patient who comes with realistic expectations, finding an effective treatment is often challenging for the treating physician.

There are various therapeutic strategies available, but so far no single modality is found solely effective. Multiple sessions using different therapeutic modalities targeting skin at different levels are often needed.

In future, more research with properly designed clinical trials with large sample size of patients, having longer follow-up periods and comparing different modalities are

Table 3b: Comparative analysis of different therapies used for striae distensae

Type of modality used in study	Type of study	Machine specifications	Frequency &total no of sittings	Results and remarks	Level of evidence
Fractional non-ablative Er glass laser vs fractional ablative CO_2 laser[27]	Comparative RCT	Er: glass laser: 1550 nm at 50 mJ CO_2 laser: 10,600 nm at 40-50 mJ	3 sessions at 4-week intervals	Clinical improvements was observed in 90.9% of striae in both treatment groups Increased skin elasticity and reduced width of striae with both treatments from baseline Increased epidermal thickness and collagen and elastic fibres with both lasers No statistically significant difference in response between either laser A/E - pain during treatment, PIH and crusting were more with the CO_2 laser	2
585 nm PDL and the short pulsed CO_2 laser[27]	RCT	PDL: 585 nm at 3 J/cm^2 CO_2 laser: 350 mJ and 400 mJ	Single session Striae split into 3 areas and treated with both lasers and 1 control area	No improvement with either treatment	2
Succinylatedatelocollagen or placebo vs succinylatedatelocollagen or placebo + ablative fractional CO_2 vs ablative fractional CO_2 laser[28]	Comparative RCT	CO_2 laser: 50 mJ Abdomen divided into 3 areas; placebo or collagen applied twice a day	3 laser sessions performed every 4 weeks	Increased epidermal thickness and erythema and melanin index in all laser irradiated sites but no significant differences between laser alone vs combination A/E - erythema, PIH, pruritus	2
Fractional ablative CO_2 vs GCA + tretinoin[29]	Comparative RCT	Group 1 - Fr CO_2-10,600 nm at 16 J/cm^2 vs Group 2-10% GCA + 0.05% tretinoin daily	5 sessions with 2-4-week intervals; GCA + tretinoin	Significantly higher clinical improvements in striae surface area in laser group compared to topicals Patient satisfaction was significantly higher in laser group A/E - PIH	2
Fractional CO_2 laser vs combination of PDL + fractional CO_2 laser[30]	Comparative RCT	Group 1- fractional CO_2 laser Group 2 - PDL + fractional CO_2 laser, Settings -- Fr CO_2 - ultra pulse, 10,600 nm, energy-140 mJ; pulse duration: 20-9540 μs, fluence: 16±2 J/cm^2; PDL (N-lite) 5-7 J/cm^2; pulse duration -0.5 ms, spot size - 7 mm	Group 13 sessions at 4 week; Group 2 - fractional CO_2 laser (3 sessions) and PDL (2 sessions) alternately, with 2-week intervals (the first session was fractional CO_2 laser)	Mean surface area decreased significantly in both groups Combination of PDL and fractional CO_2 laser was more effective	2
PDL vs IPL[46]	Comparative RCT	PDL: 595-nm at 2.5 J/cm^2; IPL: 565 nm at 17.5 J/cm^2	Five sessions with 4-week intervals	Decreased striae width and improved skin texture with both modalities SR showed better response vs SA PDL induced higher levels of collagen expression A/E - PIH erythema, pain, itching with both treatments	2

Contd...

Table 3b: Contd...

Type of modality used in study	Type of study	Machine specifications	Frequency &total no of sittings	Results and remarks	Level of evidence
XeCl excimer laser vs UVB light[49]	Comparative RCT	XeCl: 308 nm UVB: 290-320 nm	Up to 10 treatments	All patients showed increase in melanin and melanocytes with both treatments	2
Multipolar RF+pulsed magnetic field[63]	Comparative	-	6 sessions	~80% patients noticed visible improvements in SD Significant mean reduction in length and width of 1.031 cm and 0.160 cm, respectively	4
Bipolar RF+IR light vs fractional bipolar RF vs fractional bipolar RF + bipolar RF+IR light[64]	Comparative RCT	Bipolar RF+IR light: 100 J/cm^2 Fractional bipolar RF: 50-65 mJ/pin Abdomen divided into quadrants with one acting as a control	Monthly sessions for 3 months	Decrease of 21.64% in striae depth with the combined approach of all 3 treatments vs 1.73% increase in control areas No significant differences in striae width Greater clinical improvement with combined approach of all 3 treatments vs control areas More reticulated pattern of collagen fibres in combination treated and fractional bipolar RF-treated areas Thicker reticular dermis collagen fibres in all treatment areas A/E - bipolar RF: transient crusts, PIH. Mild pruritus with all treatments	1
Ablative fractional RF+tretinoin cream+acoustic pressure wave US vs ablative fractional RF[65]	Comparative RCT	RF: 45 W Tretinoin: 0.05% US: 50 Hertz 1 80% intensity	4 sessions every 4 weeks Topical tretinoin daily	All patients in combined treatment group showed clinical improvement Four patients in RF-alone group did not show any improvements All patients in combined treatment group rated improvement between 76-100% vs 25% in RF-alone group Creation of micro channels in epidermis with reaching dermoepidermal junction with combined approach A/E - erythema, oedema and burning sensation in both groups PIH with RF only	2
Plasma fractional RF+PRP+US[68]	Case control	RF: 40-45 W	Three sessions with 3-week intervals	Excellent improvement in 33%; 38.9%, very good; 22.4%, good and 5.6%, mild Average reduction in width of striae from 0.75 mm to 0.27 mm. Patients were very satisfied with treatment Significant increases in dermal collagen and elastic fibres A/E=PIH	4

Contd...

Table 3b: Contd...

Type of modality used in study	Type of study	Machine specifications	Frequency &total no of sittings	Results and remarks	Level of evidence
Carboxy therapy vs PRP[69]	Case control	PRP injection in their right side (group A) and carboxy therapy session in their left side (group B)	Every 3-4 weeks for 4 sessions	Significant improvement in striae alba in both groups after than before treatment. No significant difference between both groups as regards either percentage of improvement, response (grading scale) or patient satisfaction Increased fibronectin expression with carboxy therapy than PRP	4
PRP vs tretinoin[70]	RCT	Half of the selected striae were treated with PRP intralesional injection. The other half was treated by topical tretinoin	-	Statistically significant improvement in the SD treated with PRP and topical tretinoin cream The improvement was more in the SD treated with PRP injections. Collagen and elastic fibres in the dermis were increased in all biopsies after treatment	2
PCT vs fractional ablative CO_2[74]	RCT	PCT: Laser: 10,600 nm at 100 W	Both the treatments were given as 3 sessions with 4-week intervals	Clinical and histopathological improvements in 90% of PCT-treated group vs 50% in laser treated group	2
PCT vs MDA with sonophoresis[75]	RCT	PCT andmicrodermabrasion	PCT: 3 sessions with 4-week intervals Microdermabrasion: 10 sessions over 5 months	Clinical as well as histopathological improvements in 90% of PCT-treated group vs 50% in microdermabrasion with sonophoresis treated group	2
Superficial dermabrasion vs topical tretinoin[79]	Comparative RCT	Tretinoin (0.05%) daily Dermabrasion weekly	Topical application on daily bases vs dermabrasion weekly Both for 16 weeks	Clinical improvements with significant reductions in length and width of striae in both groups but no significant differences between treatments Reduction in elastolysis, collagen fragmentation and epidermal atrophy in dermabrasion group A/E - pruritus, erythema, burning sensation, scaling/crusting, pain, swelling, papules All present in both groups	2
Fractional ablative CO_2 laser vs IPL[83]	RCT	CO_2 laser: 10,600 nm at 40 mJ IPL: 590 nm at 20-30 J/cm^2	$FrCO_2$-5 sessions with 1-month intervals IPL - 10 sessions twice weekly for 5 months	In the laser and IPL groups, 80% and 32% were deemed to have 50% improvement, respectively Significant improvements in striae width in both groups but no significant changes in striae length In the laser group, 80% of patients were satisfied vs 20% in the IPL group A/E - erythema, burning, pruritus, PIH	2

Contd...

Table 3b: Contd...

Type of modality used in study	Type of study	Machine specifications	Frequency &total no of sittings	Results and remarks	Level of evidence
PDL vs IPL[84]	Case control	PDL-585 nm	5 sessions with a 4-week interval between	Decreased striae width, improved skin texture, increased collagen expression after PDL and IPL PDL induced the expression of collagen I in a highly significant compared with IPL Results were more in SR compared to SA	4
20% glycolic acid/0.05% tretinoin vs 20% glycolic acid/10% L-ascorbic acid[87]	Comparative RCT	GCA: 20% tretinoin: 0.05% Daily for 12 weeks to opposite sides of abdomen or thigh		Clinical and histological improvements with both regimens but no differences between individual treatments Tretinoin regimen increased reticular and papillary dermal elastin content A/E- mild irritation, dermatitis	2

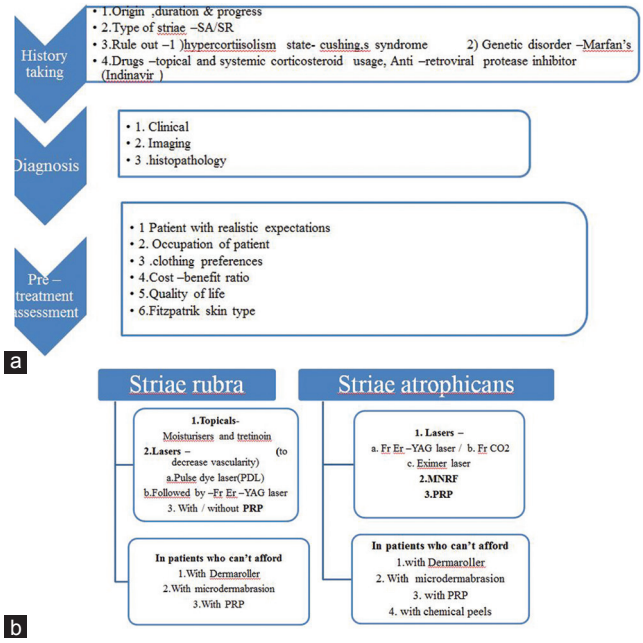

Figure 1: (a) Flowchart for management of striae distensae pre-treatment workup. (b) Flowchart for management of striae distensae – practical approach

expected to address the issue of optimum management of SD.

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Conflicts of interest

There are no conflicts of interest.

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