Therapeutic targets in the management of striae distensae: A systematic review

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Abstract: Background: Striae distensae are permanent dermal lesions that can cause significant psychosocial distress. A detailed understanding of the numerous treatment modalities available is essential to ensuring optimal patient outcomes.
Objective: To evaluate and summarize the different treatment methods for striae distensae, by linking their proposed modes of action with the histopathogenesis of the condition, in order to guide patient management.
Methods: A systematic review of the literature was performed with no limits placed on publication date. Relevant studies were assigned a level of evidence by the authors.
Results: 92 articles were identified, with 74 being eligible for quality assessment. The majority of treatments aim to increase collagen production. The use of vascular lasers can reduce erythema in striae rubrae by targeting hemoglobin, whilst increasing melanin, through methods such as UV light, is a major focus for treatment of striae albae. Despite some topical treatments being widely used, uncertainty regarding their mode of action remains. No treatment has proven to be completely efficacious.
Limitations: Low quality evidence, small sample sizes, and varying treatment protocols and outcome measures limit our findings, along with concerns regarding publication bias.
Conclusions: Further randomized controlled trials are needed before definitive conclusions and recommendations can be made.

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Dear Editor,

Thank you for accepting our systematic review for publication in JAAD, as well as providing us with suggestions for improvement regarding our tables. Please find below our response to these comments, along with a description of the changes that have subsequently been made in the revised manuscript and highlighted.

We look forward to hearing from you.

Yours sincerely,

Dr. Ardeshir Bayat

Editors comments

1. *"JAAD is on a strict page budget. Tables 1, 2, and 3 are far too long to run in the print JAAD and can run online only and will be referenced with a link in the print JAAD. The online version of JAAD (which will contain the all the tables) is the official archived version of the journal which is accessed by anyone doing a literature search (PubMed, etc.).*

   Please rename Tables 1, 2 and 3 as Supplementary Tables 1, 2 and 3 and make the same changes to their citations in the text.

   Table IV (which will run the print JAAD) should be renamed Table 1; please make the same change to its citation in the text." – Thank you for informing us of this. Tables I, II and III have been renamed as Supplemental Table II, III and IV respectively (Supplemental Table I outlining our quality rating scheme remains the same). Table IV has now been renamed Table I. Changes to their citations in the text have also been made.

2. *"Regarding current Table IV, it seems that tretinoin fits into both categories, which is a bit awkward. Please insert a footnote explaining that different studies came to opposite conclusions."*- Thank you for this suggestion. Table I (previously Table IV) has now been amended accordingly.

Therapeutic targets in the management of striae distensae:

A systematic review

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*Capsule Summary
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Capsule Summary

- Striae distensae are extremely common, permanent dermal lesions. There is great demand for an effective treatment option.
- The majority of treatments aim to increase collagen production, reduce erythema or increase pigmentation.
- Despite some positive outcomes, definitive recommendations cannot yet be made due to a lack of high quality evidence.

Abstract

Background: Striae distensae are permanent dermal lesions that can cause significant psychosocial distress. A detailed understanding of the numerous treatment modalities available is essential to ensuring optimal patient outcomes.

Objective: To evaluate and summarize the different treatment methods for striae distensae, by linking their proposed modes of action with the histopathogenesis of the condition, in order to guide patient management.

Methods: A systematic review of the literature was performed with no limits placed on publication date. Relevant studies were assigned a level of evidence by the authors.

Results: 92 articles were identified, with 74 being eligible for quality assessment. The majority of treatments aim to increase collagen production. The use of vascular lasers can reduce erythema in striae rubrae by targeting hemoglobin, whilst increasing melanin, through methods such as UV light, is a major focus for treatment of striae albae. Despite some topical treatments being widely used, uncertainty regarding their mode of action remains. No treatment has proven to be completely efficacious.

Limitations: Low quality evidence, small sample sizes, and varying treatment protocols and outcome measures limit our findings, along with concerns regarding publication bias.

Conclusions: Further randomized controlled trials are needed before definitive conclusions and recommendations can be made.

Keywords: striae distensae, striae rubrae, striae albae, stretch marks, therapy, treatment, management, systematic review.

Introduction

Striae distensae (SD), also known as stretch marks, are common, permanent dermal lesions that can be symptomatic, and are considered aesthetically undesirable. Thus, they pose a significant psychosocial and therapeutic challenge. They arise in areas of dermal stretching and most commonly occur on the abdomen, breasts, buttocks and thighs.[1-3] Most literature has described SD during pregnancy (striae gravidarum) and puberty, with reported prevalences varying from 11-88%.[1,2,4-7] Hormonal influences,[8-12] reduced genetic expression of fibronectin, collagen and elastin,[13,14] along with mechanical stretching of the skin,[2,15-17] have all been postulated to contribute to SD formation. In the acute phase, SD present as red/violaceous lesions (striae rubrae; SR) that can be raised and symptomatic.[18] The chronic form (striae albae; SA) exists as hypopigmented dermal depressions.[18,19]

Because of their high prevalence and impact on patients' quality of life,[20] there is great demand for an effective treatment. A vast array of treatment modalities have been investigated, ranging from topicals[19] and acid peel treatments,[21] to more invasive methods such as laser therapy.[22] Although completely eradicating SD is not attainable, improving appearance whilst reducing physical symptoms certainly is. It is therefore essential that clinicians managing SD have a detailed understanding of available treatment strategies in order to optimize patient outcomes and expectations.

We herein present a systematic review of SD focusing on the different treatments and their proposed modes of action with outcomes, in relation to the histopathogenesis of the condition.

Methods

Searches of both PubMed/Medline and Scopus were conducted using the keywords “stretch marks”, “striae distensae”, “striae rubra”, “striae alba”, “striae gravidarum”, AND “management”, OR “treatment”. No limits were placed on publication date, with the last literature search being conducted in November 2016. Citations of articles were also reviewed. Exclusion criteria consisted of animal/in vitro studies, non-English articles, unavailability of full text, book chapters, conference papers, letters, and reviews not specific to SD.

Data including treatment protocols, number of participants, and striae type were extracted. Relevant articles were assigned a level of evidence (LOE) independently by the authors based on a quality rating scheme modified from the Oxford Centre for Evidence-Based Medicine for ratings of individual studies (Supplemental Table I). The risk of bias was assessed for at both study and outcome level.

Results

92 articles of the 383 initially identified were included for analysis (Figure 1). 74 publications, representing 2328 patients, were relevant for quality

assessment and assigned a LOE, the results of which are as follows: level 1, 15 (20.3%); level 2, 31 (41.8%); level 4, 28 (37.8%).

Histopathogenesis

SD were first histologically described in 1889,[23] with SR and SA being histologically distinct from one another (Figure 2).[24-32] They exhibit abnormalities in three core components of skin which normally provide it with tensile strength and elasticity; collagen, elastin and fibrillin.[25-29] Early changes associated with SR include accumulation of degranulating mast cells and macrophages around mid-dermal elastic fibers, resulting in elastolysis.[24] These changes may be seen in macroscopically normal skin up to 3cm away from the lesion.[24] As the striae progress to form SA, there is gradual epidermal atrophy with loss of rete ridges.[24,25]

Treatment

Enhanced collagen production (Supplemental Table II)

The vast majority of treatments are targeted towards stimulating collagen production (Figure 3).

Topical agents

Tretinoin (retinoic acid) is believed to increase tissue collagen I levels through stimulation of fibroblasts,[19,33] and has also inhibited activation of matrix-degrading enzymes following ultraviolet (UV) induced skin damage, implying it may also protect the skin from other mechanisms of injury.[19] Numerous studies, have investigated its efficacy (LOE 1,2,4),[33,34-37] with the majority

suggesting that it can improve the appearance of early SD but not at lower doses.[35] However, study populations were small and common side effects included transient erythema[19,33,34,36,37] and scaling of the skin.[19,33,34,36]

Centella asiatica is a plant used in Asian herbal medicine. It contains asiaticoside which stimulates fibroblasts, with antagonistic effects on glucocorticoids also described.[38] Its use in the prevention of striae gravidarum has been investigated, with reported reductions in the development and severity of striae (LOE 1).[38] No side effects were observed. The use of Centella asiatica combined with boswellic acid, previously found to have anti-inflammatory effects, has also been tested.[39] Reductions in striae severity were noted, however side effects included pruritus (LOE 4).

Hyaluronic acid is also thought to increase collagen production through stimulation of fibroblasts.[40] Two RCTs (LOE 1) have reported improvements in the appearance of striae following its use, with a reported side effect being pain following treatment.[40,41] No follow up was conducted and both incorporated subjective assessments into their outcome measures.

Chemical peel treatments

Chemical peel treatments involve the application of trichloroacetic acid (TCA) or glycolic acid (GCA). They are thought to induce an initial inflammatory response, with subsequent increased collagen production.[21,42] A nonrandomized controlled trial investigating GCA reported decreases in striae furrow width, however concluded it may yield better results when used in

combination with other products.[21] GCA combined with tretinoin and L-ascorbic acid,[43] and TCA combined with the use of sand abrasion[42] or a postpeel cream[44] are such examples, all of which produced improvements in the appearance of striae. No RCTs have been performed (GCA – LOE 2, TCA – LOE 4) and postinflammatory hyperpigmentation (PIH) remains a concern.[42,44]

Mechanical techniques

Aluminum oxide microdermabrasion mechanically ablates damaged skin.[45,46] A study investigating its use in SD reported clinical improvements and increased type 1 procollagen formation (LOE 2).[46] Reported side effects included PIH.

Radiofrequency (RF) devices

RF devices deliver RF current to the skin, which is converted to heat in the dermis due to its electrical resistance.[47,48] Following initial collagen denaturation with its use, there is subsequent increased collagen production.[48] The majority of trials investigating RF for the treatment of SD have reported clinical improvements (LOE 1,2,4).[47-52] However, side effects include erythema and edema,[51,52] and the majority of trials had small cohorts.[49]

Fractional lasers

Fractional lasers deliver microscopic beams of coherent and monochromatic light energy to the skin, creating areas of thermal damage termed

microthermal zones, leading to increased dermal collagen production.[53-56] Both ablative and non-ablative lasers are available, with ablative lasers targeting water and resulting in cell vaporization.[53] Improvements in SD following treatment with a 1540-nm fractional non-ablative erbium glass (Er:glass) laser have been reported (LOE 1,2,4).[55-60] Malekzad et al[61] however, observed only a fair or poor improvement in 70% of patients with its use (LOE 4), and although improvements in SR have been described (LOE 4),[62-64] the literature suggests that non-ablative lasers are most effective on SA (LOE 4).[57] Concerns surrounding PIH also remain.[18,57,61,63]

Fractional ablative CO_2 lasers have primarily been utilized in SA, with reported clinical improvements (LOE 2,4).[65-69] Side effects include PIH. Gungor et al[70] compared the efficacy of an ablative erbium-yttrium aluminum garnet (Er:YAG) laser with a non-ablative neodymium-doped yttrium aluminum garnet (Nd:YAG) laser and found poor clinical results with both (LOE 2). When compared to non-ablative lasers, the literature suggests ablative lasers are less well tolerated and produce inconsistent results.[53]

Diode laser

The 1450-nm diode laser is a non-fractional laser, which has been shown to increase dermal collagen.[71] However, a RCT investigating its use in Fitzpatrick skin types IV-VI reported no improvements in SD, but high rates of PIH (LOE 1).[71]

Intense pulsed light (IPL)

IPL consists of a broad-spectrum (515-1200-nm) visible beam of high intensity light.[72] Studies investigating its use in SD have demonstrated increased dermal collagen levels following treatment (LOE 4).[72,73] However, a study comparing IPL against a fractional CO_2 laser for the treatment of SD, concluded that the laser was more effective (LOE 2).[74] No RCTs have yet been performed and PIH remains a cause for concern.[72,74,75]

Percutaneous collagen induction therapy (PCT)

PCT, or needling therapy, involves the creation of micro-clefts extending to the papillary dermis, resulting in increased production of collagen and elastin.[76,77] Aust et al[76] reported improvements in skin texture and tightening following treatment (LOE 4). More recently, PCT compared favorably against microdermabrasion combined with sonophoresis,[78] and a CO_2 laser (LOE 2).[79] However, there are no RCTs, and side effects include erythema.[77-79]

Platelet-rich plasma (PRP)

PRP is a concentrated solution of autologous platelets containing growth factors and cytokines injected intradermally.[45] Ibrahim et al[45] investigated its use in SD with microdermabrasion, and despite increased collagen levels following PRP treatment alone, 13% developed worsening of their striae (LOE 2). They concluded it is best to use PRP in combination with microdermabrasion. Other studies have combined PRP with RF (LOE 4)[80,81] and microneedling (LOE 2),[82] all reporting varying degrees of clinical

improvement. However, small sample sizes and no RCTs make drawing definitive conclusions difficult. Side effects include bruising.[45,80]

Infrared light

Infrared light applied to skin causes heating of the dermis and collagen denaturation, with subsequent neocollagenesis.[83] Trelles et al[83] investigated its use in the treatment of SA. Despite positive histological findings, including more pronounced rete processes, detection of improvements clinically remained low (LOE 4). Side effects were limited to erythema of the skin.

Galvanopuncture

Galvanopuncture is a needling therapy which applies a continuous microcurrent, inducing an inflammatory reaction with subsequent collagen production.[84] Bitencourt et al[84] investigated its use in SA. All patients demonstrated clinical improvements and erythema was the only side effect (LOE 4). Further trials, with histological analysis, are needed to further assess its efficacy.

Reduced vascularity (Supplemental Table III)

Vascular lasers

The 585-nm pulsed dye laser (PDL) is a commonly used vascular laser. Due to its high affinity for hemoglobin, which is present in the microvasculature of SR, it can reduce the erythema of these lesions (LOE 2).[85] Although improvements in both collagen[85,86] and elastin[87] been described following PDL treatment, these are probably subclinical and PDL is likely to have minimal

benefit in the treatment of SA (LOE 2,4).[86,88,89] Care should be taken when using PDL with darker skin types (Fitzpatrick IV to VI), as melanin competes with hemoglobin for the light energy, which can result in PIH.[85,90] Longo et al[91] tested the 577-nm copper bromide laser, which has higher rates of absorption by hemoglobin than its PDL counterpart. 33% had complete resolution of their SD with the remainder showing a reduction in striae size (LOE 4). Crusting of the skin was a reported side effect. The Nd:YAG vascular laser has also produced clinical improvements in SR (LOE 2,4), however side effects include PIH.[25,60]

Increased melanin (Supplemental Table IV)

UV light

A major aim for the treatment of SA is repigmentation of the lesion. Sadick et al[92] investigated the combined use of UVB (296-315-nm) and UVA1 (360-370-nm) light in nine individuals. Despite all patients initially having >50% improvement in pigmentation, this was only temporary and side effects included transient hyperpigmentation (LOE 2).

Excimer laser

The xenon chloride (XeCl) excimer laser delivers narrow band (308-nm) UVB radiation.[93] Its proposed advantages include being able to deliver the radiation quicker with increased precision when compared with standard UV therapy.[93] Studies have reported improvements in striae pigmentation following its use (LOE 1,4).[93,94] However, poor results were observed elsewhere (LOE 2)[95] and

splaying of the pigment to involve surrounding skin is a reported side effect.[93,95]

A study investigating UVB light therapy and the XeCl excimer laser found that both cause hypertrophy and increase of melanocytes, along with an increase in melanin, albeit not permanent.[96]

Other (Supplemental Table IV)

Bio-Oil® (Union Swiss Ltd, South Africa) consists of vitamins and plant extracts with an oil base.[97] One study investigating its use in SD demonstrated visual improvements after two weeks (LOE 2).[98] No side effects were reported.

Cocoa butter is a natural fat, and used as a topical formulation to rehydrate the skin.[99] Two trials have investigated its use in preventing SD (LOE 1).[100,101] Both failed to show any significant benefits with its use.

Soltanipoor et al[102] and Taavoni et al[103] hypothesized that, because of its high vitamin E content and moisturizing properties, olive oil could have a role in preventing striae gravidarum. However, no benefits with its use were reported (LOE 1).

Taşhan et al[104] studied the use of almond oil alone and with massage in preventing striae gravidarum formation, and observed fewest striae in those applying almond oil with massage (LOE 2). However, a RCT comparing the

effects of an Iranian produced cream (Saj®, Seoidrood Co, Iran), containing almond oil, against olive oil, found neither were effective at reducing severity of striae gravidarum (LOE 1).[105] No side effects were reported in either trial.

Silicone gel has previously been used to improve scars, with promoting skin hydration being one proposed mode of action[106] Ud-din et al[106] investigated the effect of silicone against a placebo on SD. They demonstrated increased melanin and decreases in hemoglobin and collagen with both gels. They concluded that the application of gels by topical massage can improve SD (LOE 1). No side effects were reported.

Discussion

SD are common yet undesirable permanent dermal lesions. Despite a basic understanding of the etiology and histopathological changes that occur, finding an effective treatment is proving challenging. The majority of treatment modalities are targeted towards increasing collagen production. Topical treatments in this category still lack consistent high quality evidence, with the effects of massage potentially influencing the findings. Tretinoin has had variable outcomes, with its efficacy mostly demonstrated for the treatment of SR, and despite both Centella asiatica and hyaluronic acid yielding promising results (Table I), uncertainty regarding the type of striae they are most effective against remains. Chemical peel treatments, microdermabrasion, PRP and PCT also lack high quality evidence, with no RCTs having yet been performed. Emerging techniques such as galvanopuncture look promising, however knowledge regarding its mode of action specific to SD is lacking,

along with evidenced-based trials. Lasers have been used in attempts to increase collagen production, reduce erythema in SR, and increase pigmentation in SA. Accurately interpreting these studies is difficult, owing to the small sample sizes used and short follow up periods. UV light has shown promise for the repigmentation of SA, although its lack of permanency means repeated sessions would be needed. Numerous other topicals, which mostly claim to hold moisturizing properties, are widely marketed despite lack of evidence regarding their mode of action or efficacy.

Limitations

Exclusion criteria used may have resulted in relevant studies being missed, if for example they were not published in the English language. Of those included making direct comparisons is extremely difficult, even for those using the same treatment modality, due to widely varying treatment protocols and differences in study populations. This is compounded by the different outcome measures utilized, of which none are yet validated. A large proportion assessed for improvements through the use of clinical photographs, with differences in lighting potentially influencing results. Patient satisfaction scores were also widely used, however one may question whether scores would change if the treatments were not free/provided outside the trial setting. Small sample sizes and limited follow up periods are also major limitations in a large proportion of studies. Concerns surrounding publication bias also remain, as the vast majority of papers reported some positive results.

Conclusion

Further RCTs are needed before definitive conclusions and recommendations can be made. Future work should focus on creating standardized outcome measures and treatment protocols in order to enable accurate comparisons between treatments.

Acknowledgements

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Abbreviations used

SD, striae distensae; SR, striae rubrae; SA, striae albae; LOE, level of evidence; UV, ultraviolet; RCT, randomized controlled trial; TCA, trichloroacetic acid; GCA, glycolic acid; PIH, postinflammatory hyperpigmentation; RF, radiofrequency; Er:glass, erbium glass; Er:YAG, erbium-yttrium aluminum garnet; Nd:YAG, neodymium-doped yttrium aluminum garnet; IPL, intense pulsed light; PCT, percutaneous collagen induction therapy; PRP, platelet-rich plasma; PDL, pulsed dye laser; XeCl, xenon chloride.

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Figure 1: Flow diagram outlining article selection.

Figure 2: Striae Distensae. Histological differences between normal skin (a), striae rubrae (b), and striae albae (c).

Haematoxylin and eosin stain. a) Small collagen bundles and elastin fibers gradually increase in thickness towards deeper areas of the dermis.[32] b) Perivascular lymphocyte cuffing along with dermal edema and an increase in glycosaminoglycans may be observed.[25,27,30,53] c) Collagen fibers are stretched, aligned parallel to the dermal-epidermal junction and a scanty lymphocytic infiltrate predominates.[25-28,32,53]

Figure 3: Treatments for SD and the highest LOE available for their use.

The majority of treatments are targeted towards enhancing collagen production. A large proportion of the RCTs conducted have been with topical agents, producing varying results. (LOE – level of evidence, TCA - trichloroacetic acid, GCA – glycolic acid, RF – radiofrequency, IPL – intense pulsed light, PCT – percutaneous collagen induction therapy, PRP – platelet-rich plasma, PDL – pulsed dye laser, Nd:YAG - neodymium-doped yttrium aluminum garnet, UV – ultraviolet, XeCl – xenon chloride).

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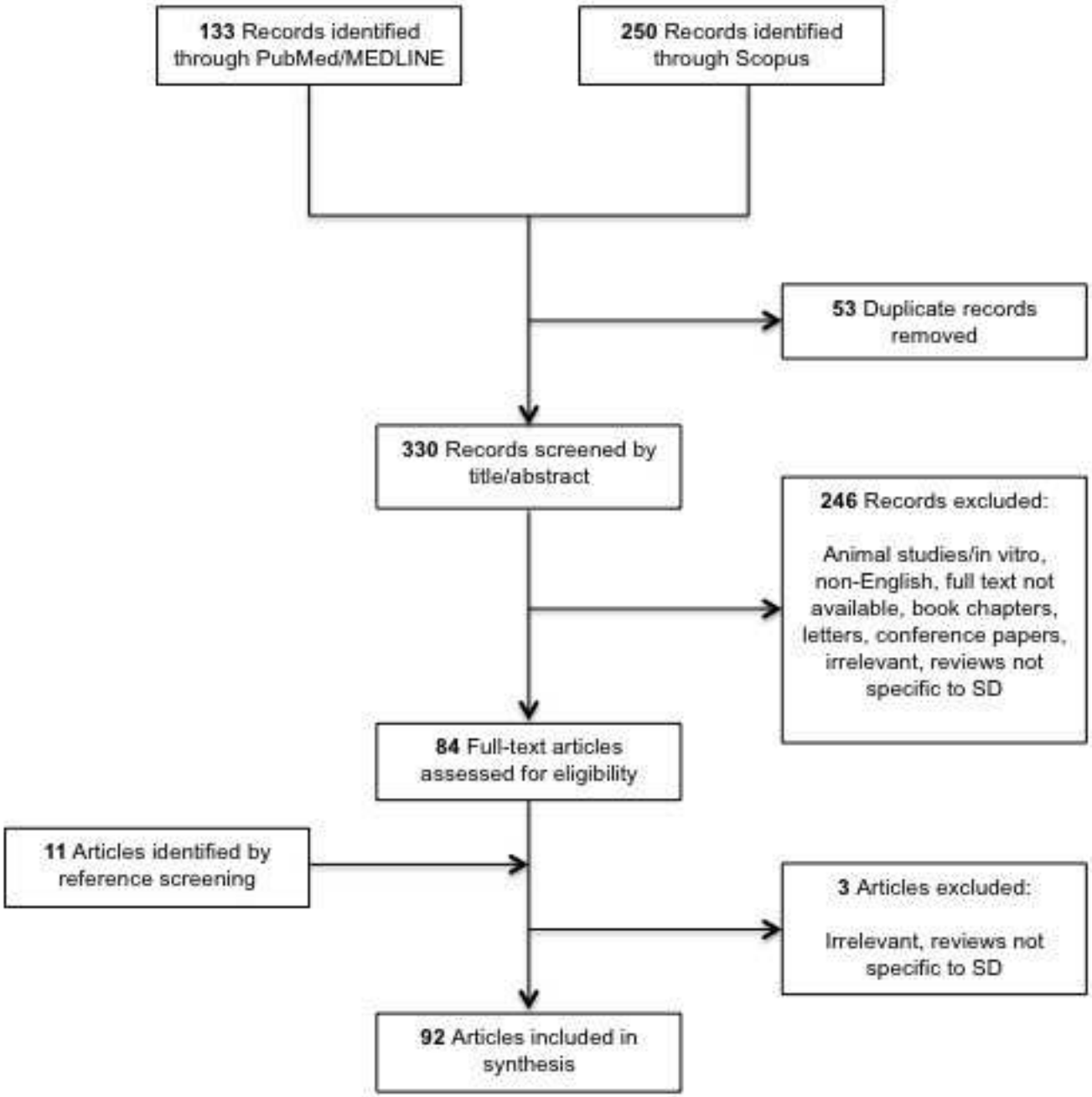

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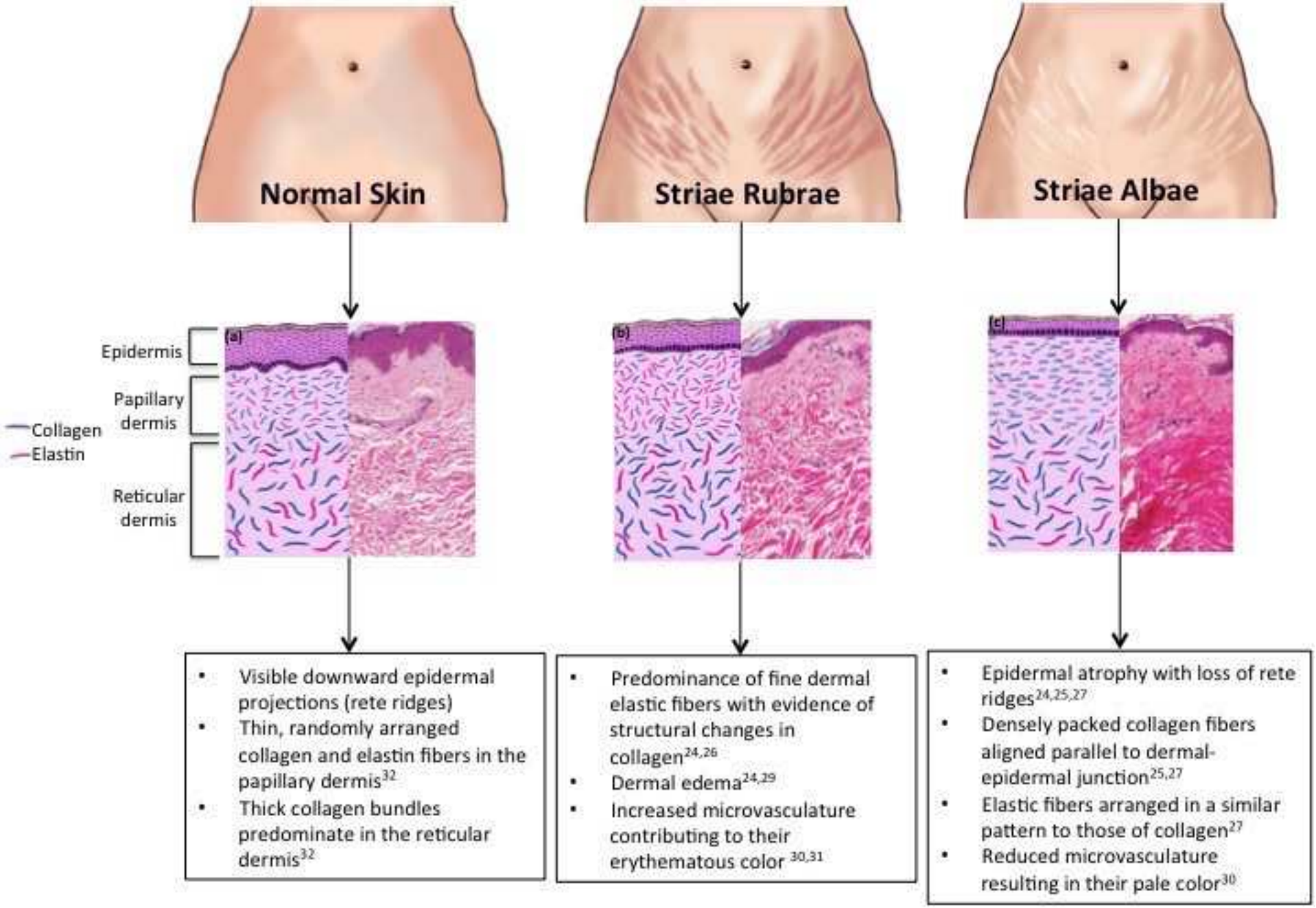

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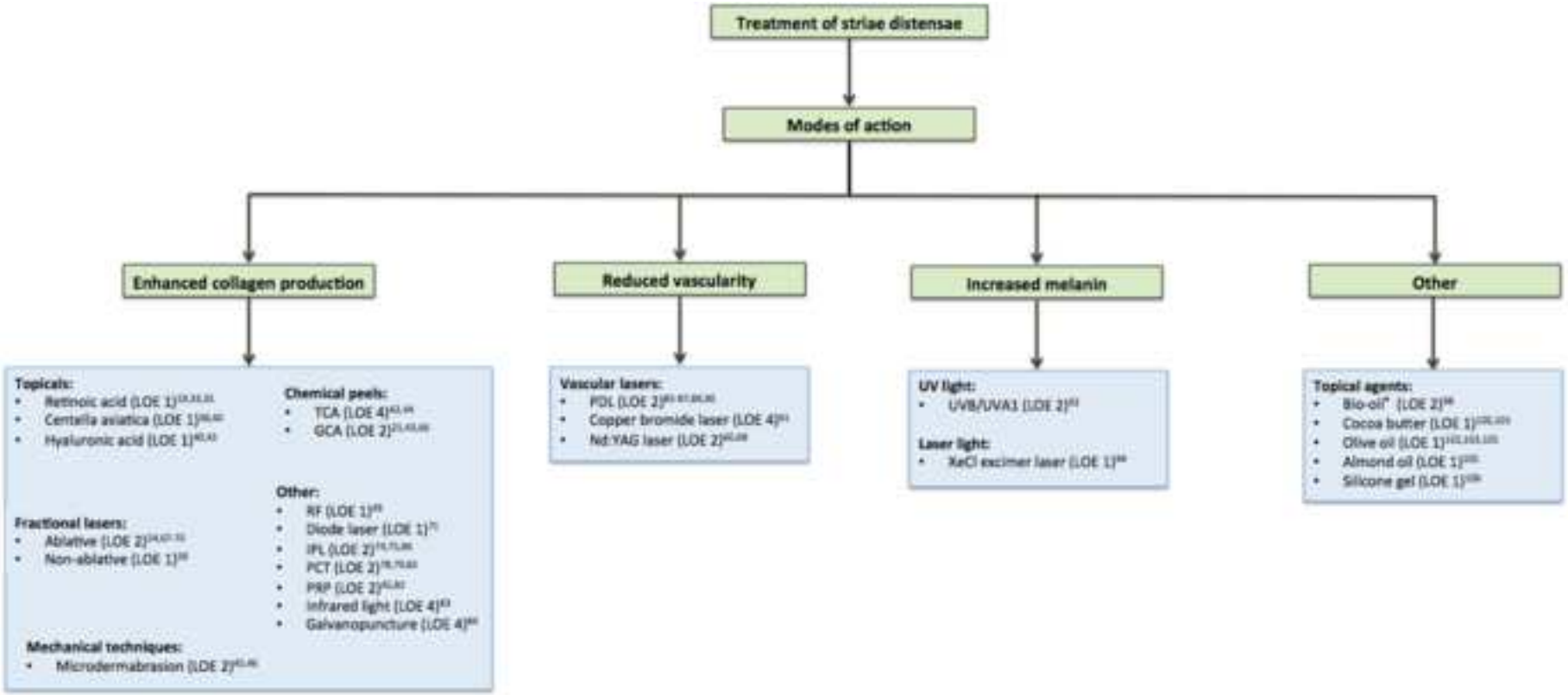

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Table I: Treatment modalities with level 1 evidence supporting their efficacy and/or ineffectiveness.

Effective	Ineffective
Tretinoin*[19,33]	Tretinoin*[35]
Centella asiatica[38,40]	Non-fractional diode laser[71]
Hyaluronic acid[40,41]	Cocoa butter[100,101]
Radiofrequency[49]	Olive oil[102,103,105]
Fractional erbium glass laser[56]	Almond oil[105]
Xenon chloride excimer laser[94]	Silicone gel[106]
*Separate studies came to opposite conclusions	

Supplemental Table I: Quality rating scheme modified from the Oxford Centre for Evidence-Based Medicine for ratings of individual studies.

Level of evidence	Study design
1	Randomized controlled trial Systematic review with meta-analysis
2	Nonrandomized controlled trial Prospective comparative cohort trial
3	Case-control study Retrospective cohort study
4	Case series Cross sectional study
5	Expert opinion Case reports

Supplemental Table II: Summary and LOE for treatments used to enhance collagen production in SD.

Author	Intervention	Dosage/ Regimen	Striae type	Sample size	Outcome measures	Results	Side effects	LOE
Kang et al[19,33]	Tretinoin cream vs. placebo	0.1% Daily for 6 months	SR	22 (10 treatment, 12 placebo)	Severity assessment scale: none, mild, moderate, severe Patient self assessment Striae length and width Histological analysis	47% reduction in mean severity score of treatment group vs. 2% increase in control 80% of treatment group had marked or definite improvement vs. 8% in control Reduction in length and width (14% and 8% respectively) in treatment group vs. increase (10% and 24% respectively) in control group No significant changes in dermal elastic or collagen fibers	Erythema Scaling Pruritus/burni-ng sensation More common in first 2 months	1
Pribanich et al[35]	Tretinoin cream vs. placebo	0.025% Daily for 7 months	SR and SA	11 (6 treatment, 5 placebo)	Severity assessment scale: none, mild, moderate, moderate-severe, severe	No significant differences between treatment and control group	Pruritus	1
Rangel	Tretinoin	0.1%	Not	20	Overall response to	80% had marked to	Erythema and	2

et al[36]	cream	Daily for 3 months to half of abdomen. Other half acted as control.	stated		treatment: -1 = worse to 4 = cleared Striae length and width	moderate global improvement Reduction in length and width by 20% and 23% respectively	scaling in first month	
Elson[37]	Tretinoin cream	0.1% Daily for 3 months	Not stated	16	Striae observations during treatment (not otherwise specified)	15 patients experienced “some benefit” with treatment Some had complete clearing of lesions (no number given)	Erythema	4
Hexsel et al[34]	Tretinoin cream vs. superficial dermabrasion	0.05% Tretinoin – daily Dermabrasio-n - weekly Both for 16 weeks	SR	22 (10 tretinoin, 12 dermabr-asion)	Global Aesthetic Improvement Scale: worse, no change, improved, much improved, very much improved Patient satisfaction: very unsatisfied, unsatisfied, neither satisfied nor unsatisfied, satisfied, very satisfied Length and width of striae Histological analysis	Clinical improvements in both groups but no significant differences between treatments Satisfaction scores (Tretinoin vs. dermabrasion): Neither satisfied nor unsatisfied 16.7% vs. 16.7%, satisfied 66.7% vs. 33.3%, very satisfied 16.7% vs. 50% Significant reductions in length and width of striae in both groups but no significant	Pruritus, Erythema Burning sensation, Scaling/crusti-ng Pain Swelling Papules All present in both groups with no significant differences between treatments	2

						differences between treatments Reduction in elastolysis, collagen fragmentation and epidermal atrophy in dermabrasion group		
Mallol et al[38]	Trofolastin (Centella asiatica, α-tocopherol, collagen-elastin hydrolisates) vs. placebo	Daily 12th week of pregnancy to labor	Not stated	80 (41 trofolasti-n, 39 placebo)	Presence of new striae and severity: 0 = no striae, 1 = few and thin, 2 = many thin or few thick, 3 = many thick	34% of treatment vs. 56% of placebo group developed striae Severity score was 1.42 in treatment vs. 2.13 in placebo group	None stated	1
Sparavi-gna et al[39]	Boswellic acid based cream with Centella asiatica, soia phospholipids and polyunsatura-ted fatty acids	Twice daily for 3 months to striae and forearm	Not stated	113	Severity score: Grade 1 = < 10 lesions, < 3 cm long and < 5 mm thick, Grade 2 = > 10 lesions, < 3 cm long, and < 5 mm thick, Grade 3 = > 10 lesions, > 3 cm long and < 5 mm thick, Grade 4 = > 10 lesions, > 3 cm long and >5 mm thick Signs of erythema,	Mean global severity score reduced by 10% Significant mean improvements in erythema (46.1%), edema (35.3%) and atrophy (29.6%) Mean increase in skin extensibility at 90 days by 3%	Pruritus Erythema Burning	4

					atrophy and edema: 1 = absent, 2 = mild, 3 = moderate, 4 = severe Skin extensibility			
Draelos et al[40]	Onion extract cream with Centella asiatica and hyaluronic acid	Twice daily for 12 weeks to thigh Opposite thigh acted as control	SR	52	Clinical assessment by patient and investigator of softness, texture, color and appearance: 0 = no improvement, 1 = minimal improvement, 2 = mild improvement, 3 = moderate improvement, 4 = marked improvement Skin elasticity	Significant mean improvements in appearance, texture, color and softness in patient and investigator evaluations vs. untreated side No significant improvements in skin elasticity	None stated	1
Morganti et al[41]	Injectable + topical hyaluronic acid, betaglucan, vit C vs. topical application	Twice weekly dermal injections with twice daily application of topical agents for 16 weeks	Not stated	66 (24 treatment injections and topical, 22 treatment topical,	Prophilometry and reduction in color/overall appearance: 0 = normal color and dermatoglyphic pattern, 0.5 = white/pinky color	Use of treatment injection and topical provided superior results in all areas when compared to both other groups Topical treatment alone had significant	Pain on injection	1

	only vs. topical placebo			20 placebo)	and dermatoglyphic pattern less evident, 1 = pink, moderately flat, 2 = intense pink, flat, 3 = violaceous, flat skin Histological analysis	improvements on the dermatoglyphic pattern and collagen bundle organization when compared with placebo		
Adatto and deprez[42]	Sand abrasion + TCA + post-peel cream (fatty acids, vit C,E,H, tretinoin precursors, algues and oligo-elements)	TCA – 15% 0.5 g post-peel cream per 10 x 10 cm area 1-8 treatments >1 month apart	SR and SA	69	Clinical appearance: 1 = fresh, inflammatory, 2a = white, superficial without laddering and palpable depressions, 2b = white, without laddering but with palpable depressions, 3a = white, with laddering <1cm width without deep pearliness, 3b = white, with laddering <1cm width with deep pearliness, 4 = white with laddering >1cm width +/- deep pearliness	70% average improvement in all types of striae	PIH particularly in darker skin types	4
Mazzare-	GCA lotion	70%	SR	40	Skin anisotropy,	Significant decrease in	None stated	2

Ilo et al[21]	vs. placebo	6 times over 6 months	and SA		furrow width and number, hemoglobin and melanin content	furrow width and hemoglobin in SR Significant decrease in furrow width in SA with an increase in melanin		
Ash et al[43]	GCA + L-ascorbic acid, zinc sulfate, tyrosine vs. GCA + Tretinoin	GCA – 20% Tretinoin – 0.05% Daily for 12 weeks to opposite sides of abdomen or thigh	SA	10	Clinical evaluation based on length, width and overall appearance Profilometry Histological analysis	Clinical improvements with both regimens but no differences between treatments No significant differences in profilometry measurements Tretinoin regimen increased reticular and papillary dermal elastin content Both increased epidermal thickness and decreased papillary dermal thickness	Mild irritation and dermatitis with both treatments	2
Deprez[44]	TCA based easy peel solution + post-peel cream	TCA – 50% Up to 8 treatments monthly	Not stated	50	Clinical appearance Depth of striae	Almost all had a 60-75% improvement Reduced depth of striae (no further information given)	PIH	4
Ibrahim et al[45]	Intradermal PRP (group	4-6 sessions at 2-week	SR and	68 (23 group 1,	Clinical assessment of improvement:	Significant clinical improvements with	Group 1 – pain on injection,	2

	1) vs. microdermab-rasion (group 2) vs. intradermal PRP + microdermab-rasion (group 3)	intervals	SA	34 group 2, 11 group 3)	worsening, no improvement, mild (<25%), moderate (25-50%), marked (50-75%), excellent (≥75%) Patient satisfaction: not satisfied (<25%), slightly satisfied (25-50%), satisfied 50-75%), very satisfied (≥75%) Histological analysis	higher patient satisfaction in groups 1 and 3 when compared to group 2. Increased dermal collagen deposition in all groups Increased epidermal thickness and rete ridges formation especially after PRP injection	ecchymosis, worsening of striae Group 2 – worsening of striae Group 3 – pain on injection, ecchymosis	
Abdel-Latif and Elbenda-ry[46]	Microdermab-rasion	5 sessions at weekly intervals Other half of body acted as control	SR and SA	20	Clinical assessment of improvement: mild (<25%), moderate (25-50%), good (50-75%), excellent (>75%) Analysis of type 1 procollagen α1 mRNA levels	Good to excellent improvement in 50% and mild to moderate improvement in the rest Greater improvement in SR Increased type 1 procollagen α1 mRNA levels in treated striae	PIH Erythema	2
Manuski-atti et al[47]	TriPollar RF device	40-50 W 6 sessions with weekly intervals	SR and SA	17	Clinical assessment of improvement: <25%, 25-50%, 51-75%, >75% Patient satisfaction: not satisfied, slightly	25-50% and 51-75% improvement in 38.2% and 11.8% of patients respectively 12%, 23% and 65% of patients were slightly	Occasional pinching sensation during treatment	4

					satisfied, satisfied, very satisfied, extremely satisfied Striae surface smoothness	satisfied, satisfied and very satisfied respectively No significant differences in striae surface smoothness		
Suh et al[48]	RF + PDL	3 sessions 4 weeks apart RF - 53-97 J/cm^2 PDL – 585-nm First session both PDL + RF were used Weeks 4+8 PDL alone was used	SR and SA	37	Clinical and patient assessment of improvement: no improvement, mild (1-25%), moderate (25-50%), good (51-75%), very good (76-100%) Histological analysis (9 patients)	89.2% showed good and very good overall improvement 59.4% graded as good and very good in elasticity Increased collagen in all with increased elastic fibers in 6 specimens	Transient purpura PIH	4
Harmelin et al[49]	Bipolar RF + IR light vs. fractional bipolar RF vs. fractional bipolar RF + bipolar RF + IR light	Bipolar RF + IR light - 100 J/cm^2 Fractional bipolar RF - 50-65 mJ/pin Monthly sessions for 3 months Abdomen	Not stated	14	Depth and width of striae Global Assessment scale: -1 = worsening of lesion, 0 = no change, 1 = slight improvement, 2 = moderate improvement, 3 =	21.64% decrease 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	Bipolar RF – transient crusts, PIH Mild pruritus with all treatments	1

		divided into quadrants with one acting as a control			marked improvement, 4 = complete clearance Reflectance confocal microscopy Histological analysis (4 patients)	improvement with combined approach of all 3 treatments vs. control areas More reticulated pattern of collagen fibers in combination treated and fractional bipolar RF treated areas Thicker reticular dermis collagen fibers in all treatment areas		
Dover et al[50]	Multipolar RF + pulsed magnetic fields	6 sessions (No further information given)	Not stated	16	Reduction in visibility Patient assessment of improvement Length and width of striae	Reduction in visibility noted in some patients (no further information given) 14 patients noticed visible improvements Significant mean reduction in length and width of 1.031cm and 0.160cm respectively	None stated	4
Issa et al[51]	Ablative fractional RF + Tretinoin cream + acoustic pressure	4 sessions every 4 weeks RF - 45 W Tretinoin - 0.05%	SA	16 (8 combinat-ion therapy, 8 RF alone)	Clinical assessment of severity: 0 = none, 1 = mild, 2 = moderate, 3 = marked, 4 = severe Patient assessment	All patients in combined treatment group showed clinical improvement 4 patients in RF alone group did not show any improvements	Erythema, edema and burning sensation in both groups PIH with RF	2

	wave US vs. ablative fractional RF	US - 50 Hertz + 80% intensity			of improvement: 0 = no improvement, 1 = 25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100% Histological analysis (3 patients)	All patients in combined treatment group rated improvement between 76-100% vs. ≤25% in RF alone group Creation of micro-channels in epidermis with ink reaching dermo-epidermal junction with combined approach	only	
Mishra et al[52]	Ablative fractional micro-plasma RF	4 sessions every 2 weeks	SR and SA	5	Clinical assessment of severity on a scale of 1-4 (4 = most severe) Patient assessment of improvement on a scale of 0-4 (4 = marked improvement)	Mean severity score improved by 20% Mean score from patient assessment was 2.4 (good to very good)	Erythema Edema	4
Shin et al[54]	Succinylated atelocollagen or placebo vs. succinylated atelocollagen or placebo + ablative fractional CO_2 laser vs.	3 laser sessions performed every 4 weeks CO_2 laser - 50 mJ Abdomen divided into 3 areas	SA	12	Clinical improvement: 0 = no improvement, 1 = 1-25%, 2 = 26-50%, 3 = 51-75%, 4 = 76-100% Erythema and melanin index Histological analysis (6 patients)	Clinical improvements noted by physicians in areas receiving laser therapy alone or as combination treatment vs. placebo No significant improvements noted by patients Increased epidermal	Erythema PIH Pruritus Psoriasis (Occurrence rates with each treatment not stated)	2

	ablative fractional CO_2 laser	Placebo or collagen applied twice a day				thickness and erythema and melanin index in all laser irradiated sites but no significant differences between laser alone vs. combination		
de Angelis et al[55]	Fractional non-ablative Er:glass laser	1450-nm at 12-55 mJ/mb 2-4 sessions with 4-6 week intervals	SR and SA	51	Clinical improvement: 0= 0%, 1 = 1-25%, 2 = 26-50%, 3 =51-75%, 4 = 76-99%, 5 = 100% Histological analysis (3 patients)	Nonblinded assessment - ≥50% improvement Blinded assessment – 51-75% improvement Thickening of epidermis and dermis, increased elastin deposition and neocollagenesis	Edema Erythema PIH	4
Stotland et al[56]	Fractional non-ablative Er:glass laser	1550-nm at 12-18 J/cm^2 6 sessions with 2-3 week intervals Untreated site matched striae acted as controls	SR and SA	20	Clinical improvement: 1 = ≤25%, 2 = 26-50%, 3 = 51-75%, 4 = ≥76%	63% of patients had 26-50% improvement <25% improvement in dyschromia was noted in 50% 26-50% improvement in texture was observed in 50% of patients	Erythema Edema Blistering	1
Bak et al[57]	Fractional non-ablative Er:glass laser	1550-nm at 30 mJ 2 sessions with a 4 week interval	SR and SA	22	Clinical improvement: 1 = <25%, 2 = 25-50%, 3 = 51-75%, 4 = 76-100%	Mean clinical improvement graded as 1.5 Best results observed in SA	Erythema Crusting PIH	4

					Histological analysis	Increased epidermal and dermal thickness		
Clement-oni and Lavagno-[58]	Fractional non-ablative Er:glass laser	1565-nm at 50-55 J/cm^2 3 sessions with 4-5 week intervals	Not stated	12	Clinical improvement: 0%, 1-25%, 26-50%, 51-75%, 76-100% Patient satisfaction: none, slight, moderate, good, very good Volume of depressions and color of striae	51-75% clinical improvement observed in all patients Moderate to good satisfaction recorded by all patients 91.7% and 83.3% showed >50% improvement in volume and color respectively	Erythema Edema Crusting	4
Wang et al[59]	Fractional non-ablative Er:glass laser	Abdomen split into 2 and treated with 1540-nm at 50 J/cm^2 vs. 1410-nm at 30 J/cm^2 6 treatments at 3-6 week intervals	SR and SA	9	Clinical improvement: no improvement, mild (0-25%), Fair (26-50%), good (51-75%), excellent (76-100%) Patient satisfaction Histological analysis (2 patients)	All patients demonstrated clinical improvement 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 Increased epidermal thickness, dermal thickness and collagen	Pain and PIH particularly with 1540-nm and 1410-nm lasers respectively Pruritus	2

						and elastin density vs. baseline with no significant differences between lasers		
Malekza-d et al[61]	Fractional non-ablative Er:glass laser	1540-nm at 50-70 J/cm^2 4 sessions at 4 week intervals	SA	9	Clinical improvement: 1 = 0%, 2 = 1-24%, 3 = 25-64%, 4 = 65-94%, 5 = 95-100%	Clinical improvement observed in 70% (50% - 1-24% improvement, 20% - 25-64% improvement)	PIH	4
Kim et al[18]	Fractional non-ablative Er:glass laser	1550-nm at 15 mJ/MTZ 1 session Normal adjacent skin and untreated striae used as controls	SA	6	Clinical appearance Patient satisfaction: -100 (very unsatisfactory) to +100 (very satisfactory) Skin elasticity Erythema and melanin index Histological analysis	Improvements in macroscopic appearance Mean satisfaction score of 55 No significant changes in skin elasticity and no overall improvements in erythema and melanin index scores when compared with control Significant increases in epidermal thickness and collagen and elastic fiber deposition following laser treatment	Treatment-related pain PIH	2
Alves et al[62]	Fractional non-ablative Er:glass laser	1540-nm at 70 mJ/MTZ 3-6 sessions	SR	4	Clinical appearance	After 3 sessions clinical improvement was noted in 2 patients	Erythema Edema	4

		at 1 month intervals				Clinical improvement was noted in the remaining 2 patients after 4 and 6 sessions respectively		
Guimarã-es et al[63]	Fractional non-ablative Er:glass laser	1550-nm at 80-100 mJ/MTZ 4-8 sessions at 4 week intervals	SR	10	Clinical improvement and patient satisfaction score: 0 (no improvement) – 10 (total improvement)	Mean clinical improvement of 8.4 after an average of 6.5 sessions Mean patient satisfaction score of 8.2	PIH	4
Katz et al[64]	Fractional non-ablative Er:glass laser	1550-nm at 20-70 mJ/MTZ 3-5 sessions at 4 week intervals	SR	2	Clinical appearance Patient satisfaction	>75% improvement in both patients Both patients highly satisfied with results	Erythema Edema	4
Lee et al[65]	Fractional ablative CO_2 laser	10,600-nm at 10 mJ/MTZ 1 session Retrospectiv-ely reviewed	SA	27	Clinical improvement: 0 = worsened, 1 = 0-25%, 2 = 26-50%, 3 = 51-75%, 4 = >75% Patient satisfaction: unsatisfied, slightly satisfied, satisfied, very satisfied	7.4% had grade 4 improvement, 51.9% had grade 3 improvement, 33.3% had grade 2 improvement and 7.4% had grade 1 improvement 22.2% of patients were very satisfied, 51.9% were satisfied, 18.1% were slightly satisfied,	PIH Pruritus Crusting Oozing Erythema	4

						7.4% were unsatisfied		
Naeini and Soghrati-[66]	Fractional ablative CO_2 laser (group 1) vs. GCA + Tretinoin (group 2)	10,600-nm at 16 J/cm^2 5 sessions with 2-4 week intervals 10% GCA + 0.05% Tretinoin daily Striae from same individual randomly assigned to different treatment groups	SA	6	Clinical improvement: weak = 0-25%, moderate = 25-50%, good = 50-75%, excellent = >75% Patient satisfaction: 0 (no improvement) to 10 (complete improvement) Surface area of striae	Significantly higher clinical improvements in group 1 (27%) vs. group 2 (5.2%) Mean difference in striae surface area significantly lower in group 1 (-37.1 cm) vs. group 2 (-7.9 cm) Mean patient satisfaction scores significantly higher in group 1 (3.05) vs. group 2 (0.63)	PIH	2
Yang and Lee[67]	Fractional non-ablative Er:glass laser vs. Fractional ablative CO_2 laser	Er:glass laser - 1550-nm at 50 mJ CO_2 laser - 10,600-nm at 40-50 mJ 3 sessions at 4 week intervals Treatments randomized	SA	22	Clinical improvement: 0 = no improvement, 1 = <25%, 2 = 26-50%, 3 = 51-75%, 4 = >76% Patient satisfaction: 0 = not satisfied, 1 = slightly satisfied, 2 = satisfied, 3 = very satisfied, 4 =	Clinical improvements observed in 90.9% of striae in both treatment groups Increased skin elasticity and reduced width of striae with both treatments from baseline 81.8% of patients judged their striae as	Pain during treatment, PIH and crusting were seen with both lasers but noted to be worse with the CO_2 laser	2

		to either side of abdomen			extremely satisfied Width of widest striae Skin elasticity Histological analysis	improved vs. 90.9% in the Er:glass and CO_2 laser groups respectively Increased epidermal thickness and collagen and elastic fibers with both lasers No significant differences existed between either laser		
Naeini et al[68]	Fractional ablative CO_2 laser + fractionated microneedle RF vs. fractionated microneedle RF	CO_2 laser - 10,600-nm at 16 J/cm^2 Laser + RF - 5 sessions with 4 week intervals RF only – 3 sessions with 4 week intervals Opposite sides of body randomly assigned to each treatment group	SA	6	Clinical improvement: 0-25%, 25-50%, 50-75%, >75% Patient satisfaction: 0 (lack of improvement) to 10 (complete improvement) Surface area of striae	Significantly higher clinical improvement and patient satisfaction scores in CO_2 laser + RF group vs. RF alone Greater reductions in mean surface area of striae with CO_2 laser + RF vs. RF alone	Erythema in both groups PIH in CO_2 laser + RF group	2

Ryu et al[69]	Fractional ablative CO_2 laser vs. fractionated microneedle RF vs. combination	CO_2 laser – 700 to 1000 mJ RF – 4-7 intensity 3 treatment sessions with 1 month intervals	Not stated	30 (10 per group)	Clinical improvement: 1 = 0-30%, 2 = 30-50%, 3 = 51-80%, 4 = ≥81% Histological analysis (2 patients)	Mean clinical improvement was 2.2 in CO_2 laser only group, 1.8 in RF only group and 3.4 in combination group Thickened epidermis and increased collagen in combination group	PIH Pain Pruritus	2
Gungor et al[70]	Ablative Er:YAG laser vs. non-ablative Nd:YAG laser	Er:YAG laser - 2940-nm at 3.2 J + 1 J Nd:YAG laser - 1064-nm at 50 J/cm^2 3 sessions at monthly intervals Treatments randomized to either side of abdomen	SR and SA	20	Clinical improvement: <33% = poor, 33-66% = moderate, >66% = good Histological analysis (6 patients)	Those with SA had a poor response to both lasers (17 patients) Those with SR had a moderate response to both lasers (3 patients) No change in epidermal or dermal thickness Collagen fibers following Nd:YAG treatment showed decrease parallelism compared to Er:YAG treated side	Erythema and PIH with Er:YAG laser	2
Tay et al[71]	Non-ablative diode laser	1450-nm at 4,8 and 12 J/cm^2 3 sessions with 6 week intervals Opposite side	SR and SA	11	Clinical improvement: 1 = ≤25%, 2 = 26-50%, 3 = 51-75%, 4 = >75% Patient satisfaction: A = not satisfied, B	No noticeable improvements when compared with control No patients were satisfied with treatment	Erythema PIH	1

		of body acted as control			= somewhat satisfied, C = highly satisfied			
Hernánd-ez-Perez et al[72]	IPL	515-1200-nm 5 sessions with 2 week intervals	SA	15	Clinical improvement: scale by crosses – 0 = no improvement, + = mild, ++ = moderate, +++ = good, ++++ = very good Length and number of striae Histological analysis	Clinical improvement was moderate in 40%, good in 20% and very good in 40% Reduced total length and number of striae Improved collagen fiber quality Increased dermal thickness (2.03 mm pre treatment vs. 3.31 mm post treatment)	PIH	4
Bedewi and Khalafa-wy[73]	IPL	535, 550 + 580 nm at 25-35 J/cm^2 5 sessions with 3-4 week intervals	SR and SA	24	Synchrotron IR microspectroscopic study of dermal fibroblasts Histological analysis	Increased collagen, amide1 and beta sheet expression following IPL treatment	Stinging sensation	4
El Taieb and Ibrahim[74]	Fractional ablative CO_2 laser vs. IPL	CO_2 laser - 10,600-nm at 40 mJ 5 sessions with 1 month intervals IPL - 590-nm at 20-30	Not stated	40 (20 laser, 20 IPL)	Clinical improvement: 1 = ≤50%, 2 = >50% Width and length of striae Patient satisfaction: none or less satisfied = 0,	80% and 32% were deemed to have ≥50% improvement in the laser and IPL groups respectively Significant improvements in striae width in both groups but	Erythema Burning Pruritus PIH (Occurrence rates within each treatment group not	2

		J/cm^2 10 sessions twice weekly for 5 months			satisfied = 1	no significant changes in striae length 80% of patients were satisfied in laser group vs. 20% in IPL group	stated)	
Al-Dhalimi Abo Nasyria[75]	IPL	650-nm at 13-15.5 J/cm^2 vs. 590-nm at 13-14.5 J/cm^2 5 sessions with 2 week intervals Different wavelengths used on opposite sides of body	SR	20	Sum of length and width of striae Erythema: 0-1 white, >1-4 mild, >4-7 moderate, >7-10 severe Patient satisfaction: weak, partial, very good	Significant reductions in length and width with both treatments Significant reduction in erythema with 590-nm wavelength along with superior patient satisfaction scores	Erythema Pain Burning PIH All more common with 590-nm wavelength	2
Aust et al[76]	PCT	1 session	Not stated	22	Skin texture, tightness, pigmentation Histological analysis	Improved skin texture, tightening and dermal neovascularization No change in pigmentation Increased collagen I and elastin No change in collagen III	None stated	4
Park et al[77]	PCT	3 sessions with 4 week intervals	SR and SA	16	Clinical improvement: no change (0%),	Marked to excellent improvement in 43.8% with minimal to	Pain Erythema Spotty	4

					minimal (<25%), moderate (26-50%), marked (51-75%), excellent (76-100%) Patient satisfaction: unsatisfied, somewhat satisfied, highly satisfied Histological analysis	moderate in the remaining patients 37.5% were highly satisfied, 50% somewhat satisfied, 12.5% unsatisfied Increased dermal elastin and collagen	bleeding	
Nassar et al[78]	PCT vs. microdermab-rasion + sonophoresis	PCT - 3 sessions with 4 week intervals Microdermab-rasion – 10 sessions over 5 months	SR and SA	40 (20 PCT, 20 microder-mabrasi-on)	Clinical improvement: no improvement, mild (≤25%), moderate (26-50%), good (51-75%), excellent (≥76%) Patient satisfaction: not satisfied, slightly satisfied, satisfied, very satisfied, extremely satisfied Histological analysis	Clinical improvements in 90% of PCT treated group vs. 50% in microdermabrasion + sonophoresis treated group Significantly higher satisfaction scores with PCT Epidermal thickness, number of fibroblasts and collagen levels were increased in 90% and 50% of the PCT and microdermabrasion + sonophoresis treated groups respectively	Erythema PIH (more common in microdermabr-asion + sonophoresis group)	2
Khater et al[79]	PCT vs. fractional ablative CO_2	PCT – 3 sessions with 4 week	SR and SA	20 (10 PCT, 10 laser)	Clinical improvement: none, mild (≤25%),	Clinical improvements in 90% of PCT treated group vs. 50% in laser	Erythema PIH (more common in	2

		intervals Laser – 10,600-nm at 100 W 3 sessions with 4 week intervals			moderate (26-50%), good (51-75%), excellent (≥76%) Patient satisfaction: not satisfied, slightly satisfied, satisfied, very satisfied, extremely satisfied Histological analysis	treated group Significantly higher satisfaction scores with PCT Epidermal thickness, number of fibroblasts and collagen levels were increased in 90% and 50% of the PCT and laser treated groups respectively	laser treated group)	
Kim et al[80]	Intradermal RF + PRP	3 sessions with 4 week intervals RF - 12 W	Not stated	19	Clinical improvement: no change, mild (0-25%), moderate (25-50%), marked (50-75%), excellent (75-100%) Patient satisfaction: unsatisfied, slightly satisfied, satisfied, very satisfied	Excellent improvement in 5.3%, 36.8% marked improvement, 31.6% moderate improvement, 26.3% mild improvement 63.2% of patients satisfied or very satisfied with improvement	Bruising	4
Suh et al[81]	Plasma fractional RF + PRP + US	RF - 40-45 W 3 sessions with 3 week intervals	SA	18	Clinical improvement: no improvement, mild (<25%), moderate (25-49%), good (50-74%), excellent (>75%)	Excellent improvement in 33%, 38.9% very good, 22.4% good, 5.6% mild Average reduction in width of striae from 0.75 mm to 0.27 mm	PIH	4

					Length and width of striae Patient satisfaction: not satisfied, slightly satisfied, satisfied, very satisfied, extremely satisfied Histological analysis (3 patients)	72.2% of patients were very satisfied or extremely satisfied Significant increases in dermal collagen and elastic fibers		
Agamia et al[82]	PCT vs. PCT + PRP	4 sessions with 2 week intervals PCT alone on right side of body with left side receiving PCT + PRP	Not stated	20	Clinical improvement: none, minimal, moderate, marked Histological analysis	PCT alone - 20% showed marked improvement, 40% moderate improvement, 40% minimal improvement PCT + PRP – 50% marked improvement, 35% moderate improvement, 15% minimal improvement Significant increase in collagen in PCT + PRP group	None stated	2
Trelles et al[83]	Infrared light	800-1800-nm at 31 J/cm^2 4 sessions with 15 day intervals	SA	10	Clinical improvement: worse, same, fair, good, very good Striae depth	4 patients reported improvement as fair, 4 as same and 2 as good 25-50% improvement in striae depth	Erythema	4

					Histological analysis (2 patients)	More pronounced rete processes with tightening of dermis		
Bitencourt et al[84]	Galvanopuncture	10 sessions once a week at 200 μA	SA	32	Clinical improvement: no improvement, slight (1-25%), moderate (26-50%), good (51-75%), very good (76-100%) Plasma inflammatory marker levels Cholesterol levels Antioxidant activity	Very good and good improvement in 53% and 47% respectively No significant increase in inflammatory markers No significant changes in cholesterol levels No change in antioxidant activity however overall decrease in oxidative injury	Erythema	4
LOE – level of evidence, SR – striae rubrae, SA – striae albae, TCA – trichloroacetic acid, GCA – glycolic acid, PRP – platelet-rich plasma, RF – radiofrequency, US – ultrasound, Er – erbium, Er:YAG – erbium-yttrium aluminum garnet, IPL – intense pulsed light, Nd:YAG – neodymium-doped yttrium aluminum garnet, PCT – percutaneous collagen induction therapy, PIH – postinflammatory hyperpigmentation								

Supplemental Table III: Summary and LOE for treatments used to reduce vascularity in SD.

Author	Intervention	Wavelength/ Regimen	Striae type	Sample size	Outcome measures	Results	Side effects	LOE
Goldman et al[25]	Long-pulsed Nd:YAG laser	1064-nm at 80-100 J/cm^2 Average number of treatment sessions was 3.45 with 3-6 week intervals	SR	20	Clinical improvement: poor = ≤30%, good = 30-70%, excellent = >70%	Improvement rated as excellent by 55% of patients and 40% of doctors	Edema Erythema	4
Elsaie et al[60]	Long-pulsed Nd:YAG laser	Striae divided into 3 sections and treated with 1064-nm at 75 J/cm^2 vs. 100 J/cm^2 vs. control 4 treatments at 3 week intervals	SR and SA	45	Global Aesthetic improvement scale: 1 (much improved) to 5 (no change) Patient satisfaction: 1 (very satisfied) to 5 (very unsatisfied) Length and width of striae Histological analysis (6 patients)	Clinical improvements in SA and SR with both fluencies Better results in SA observed using 100 J/cm^2 All patients satisfied with results (no further information given) Significant improvements in length and width of striae in both groups Increased collagen and elastin fibers with both fluencies	Pain PIH (Occurrence rates for each fluence not stated)	2

Jimeén-ez et al[85]	PDL	585-nm at 3 J/cm^2 2 treatments 6 weeks apart Untreated striae acted as controls	SR and SA	20	Striae area and color Histological analysis	No significant differences in striae area in treatment vs. control striae Improvement in color in SR No improvement in SA Increased collagen in treated striae	PIH	2
Shokeir et al[86]	PDL vs. IPL	PDL - 595-nm at 2.5 J/cm^2 IPL - 565-nm at 17.5 J/cm^2 5 sessions with 4 week intervals Body area split into two with each side receiving one of the treatments	SR and SA	20	Clinical improvement: 0-5 Striae width Skin texture Histological analysis	Striae width decreased and skin texture improved with both treatments SR showed greater clinical improvements vs. SA PDL induced higher levels of collagen I expression	Erythema, pain, itching and PIH recorded with both treatments	2
McDaniel et al[87]	PDL	585-nm 4 treatment protocols (spot diameter, fluence): 1 =	SR and SA	39	Percentage return to normal visual skin patterns Skin shadowing using shadow profilometry	Best results observed with 10 mm spot size + 3 J/cm^2 fluence All protocols reduced skin shadowing Elastin appeared normal	Purpura Erythema Hyperpigment-ation Hypopigment-ation	2

		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 acted as controls			Histological analysis	with low fluencies	(Occurrence rates for each protocol not stated)	
Nehal et al[88]	PDL	585-nm at 4.25 J/cm^2 Sessions at 2-month intervals for 1-2 years	SA	5	Clinical appearance Striae texture Histological analysis	All 5 patients reported mild improvements in appearance Independent investigators reported minimal to no improvements Improved surface texture in 3 patients No significant histological changes	PIH in darker skin types	4
Gauglitz et al[89]	PDL vs. fractional ablative Er:YAG laser	PDL - 585-nm at 7 J/cm^2 Er:YAG laser – 2940-nm at 72 J/cm^2 5 sessions with 4-5 intervals Each axilla	SR	2	Clinical appearance Patient satisfaction Skin texture	Greater improvements with Er:YAG laser reported in first patient Similar improvements with both treatments reported in second patient Both patients favored Er:YAG laser	PIH Erythema Pruritus Crusting	2

		received one of the two treatments						
Nouri et al[90]	PDL vs. short pulsed CO_2 laser	PDL – 585 nm at 3 J/cm^2 CO_2 laser – 350 mJ and 400 m J 1 session Striae split into 3 areas and treated with both + control area	Not stated	4	Clinical improvement: “did the treated areas look more like normal skin than the untreated control?”	No improvement with either treatment	PIH with both Erythema with CO_2 laser	2
Longo et al[91]	Copper bromide laser	577 nm at 4-8 J/cm^2 1-5 sessions with 1 month intervals	Not stated	15	Clinical improvement: Poor, less, good, excellent Striae width, depth and color	5 patients had total disappearance of striae 8 patients had good improvement 2 patients improvements were categorized as less Results maintained at 2 years in 13 patients	Burning Crusting	4
LOE – level of evidence, SR – striae rubrae, SA – striae albae, Nd:YAG – neodymium-doped yttrium aluminum garnet, PDL – pulsed dye laser, IPL – intense pulsed light, Er:YAG – erbium-yttrium aluminum garnet, PIH – postinflammatory hyperpigmentation								

Supplemental Table IV: Summary and LOE for treatments used to increase melanin in SD and various other topicals.

Author	Intervention	Dosage/ Regimen	Striae type	Sample size	Outcome measures	Results	Side effects	LOE
Sadick et al[92]	UVB/UVA1 light therapy	UVB - 296-315 nm + UVA – 360-370 nm at 45-400 mJ/cm^2 Twice weekly treatments for a maximum of 10 treatments Adjacent area acted as control	SA	9	Repigmentation: 0-25%, 26-50%, 51-75%, 76-100%, >100% Histological analysis (2 patients)	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 fiber to collagen ratio in 1 patient	Erythema PIH	2
Goldberg et al[93]	XeCl excimer laser	308 nm at 150-900 J/cm^2 Up to 15 sessions	SA	75	Repigmentation: none (0%), mild (1-25%), moderate (26-75%), substantial (76-100%) Patient evaluations: worsened, no change, improved Erythema: none,	All subjects achieved ≥76% darkening of their striae 80% noted improvement in appearance of striae Mild to moderate erythema in all patients	Splaying of pigment	4

					mild, moderate, severe			
Alexiad-es-Arme-nakas et al[94]	XeCl excimer laser	308 nm at minimal erythema dose minus 50 mJ/cm^2 Up to 10 sessions with 2 week intervals Site matched controls used	SA	9	Repigmentation: 0-100% by visual and colorimetric assessment	Mean pigmentation correction after 9 treatments by visual and colorimetric assessment of 68% and 102% respectively vs. control Both values declined over 6-months	Erythema	1
Ostovari et al[95]	XeCl excimer laser	308 nm Up to 10 sessions with weekly intervals	SA	10	Repigmentation and patient satisfaction: poor (0-25%), moderate (26-50%), good (51-75%), very good (76-100%) Colorimetric analysis	80% of patients had poor or moderate results 70% of patients rated their results as poor or moderate Poor effect on repigmentation	Splaying of pigment	2
Goldberg et al[96]	XeCl excimer laser vs. UVB light	XeCl – 308 nm UVB – 290-320 nm Up to 10 treatments	SA	10 (5 XeCl laser, 5 UVB light)	Histological analysis of melanocytes	Increase in melanin Hypertrophy and increase of melanocytes with both treatments	None stated	2
Summe-	Bio-oil®	Twice daily	Not	20	Patient and	Significant	None stated	2

rs et al[98]		Abdomen split into two with one half acting as a control	stated		Observer Scar Assessment Scale: 5 parameters (vascularization, pigmentation, thickness, relief, pliability) graded 1 (best) to 10 (worst) Subjective clinical evaluation	improvements in treated striae vs. untreated striae		
Buchan-an et al[100]	Cocoa butter vs. placebo	Daily 12-15 weeks gestation until delivery	Not stated	300 (150 treatment, 150 placebo)	Development of new striae: 0 (no striae) to 4 (severe striae)	No significant differences in the development of new striae between treatment vs. placebo group	Mild self-limiting allergic reaction	1
Osman et al[101]	Cocoa butter vs. placebo	Daily 12-18 weeks gestation until delivery	Not stated	175 (91 treatment, 84 placebo)	Development of new striae and severity: 1 = mild, 2 = moderate, 3 = severe	No significant differences in the development or severity of striae between treatment vs. placebo	None stated	1
Soltanip-oor et al[102]	Olive oil	Twice daily 18-20 weeks until 38-40 weeks gestation	Not stated	100 (50 treatment, 50 control)	Development of new striae and severity: 0 = none, 1 = few, 2 = numerous	No significant differences in the development or severity of striae between treatment vs. control	None stated	1
Taavoni et al[103]	Olive oil	Twice daily 18-20 weeks gestation for	Not stated	70 (35 treatment, 35	Development of new striae	No significant differences in the development of striae	None stated	1

		8 weeks		control)		between treatment vs. control		
Taşhan and Kafkasli[1-04]	Almond oil vs. almond oil + massage	Every other day from 19 to 32 weeks gestation Daily from 32 weeks gestation until delivery	Not stated	141 (48 almond oil, 47 almond oil with massage, 46 control)	Development of new striae	Significant differences observed between all 3 groups Almond oil + massage group developed fewest striae	None stated	2
Soltanip-our et al[105]	Olive oil vs. Saj® cream (Ianolin, stearin, triethanolami-ne, almond oil and bizovax glycerin amidine)	Twice daily from 18-20 weeks until 38-40 weeks gestation Untreated subjects acted as controls	Not stated	150 (50 olive oil, 50 Saj®, 50 control)	Development of new striae: abdomen divided into 4 quadrants – 0 = no striae, 1 = striae which do not affect a quadrant completely, 2 = striae which affect a quadrant completely 1-3 = mild, 4-6 = moderate, 7-8 = severe	No significant differences in the development or severity of striae between any of the groups	None stated	1
Ud-din et al[106]	Topical silicone gel vs. placebo	Daily for 6 weeks Placebo applied to opposite side of abdomen	Not stated	20	Severity, self conscious and impact scores Histological analysis	No significant changes in severity, self conscious or impact scores Decreased hemoglobin and collagen with	None stated	1

						increased melanin in both silicone and placebo treated sides Collagen levels significantly higher with lower melanin levels in treatment group vs. placebo		
LOE – level of evidence, SR – striae rubrae, SA – striae albae, XeCl – xenon chloride, PIH – postinflammatory hyperpigmentation								

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