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Review

Striae gravidarum: Risk factors, prevention, and management☆

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ABSTRACT

Background: Striae gravidarum (SG) are atrophic linear scars that represent one of the most common connective tissue changes during pregnancy. SG can cause emotional and psychological distress for many women. Research on risk factors, prevention, and management of SG has been often inconclusive.
Methods: We conducted a literature search using textbooks, PubMed, and Medline databases to assess research performed on the risk factors, prevention, and management of SG. The search included the following key words: striae gravidarum, pregnancy stretch marks, and pregnancy stretch. We also reviewed citations within articles to identify relevant sources.
Results: Younger age, maternal and family history of SG, increased pre-pregnancy and pre-delivery weight, and increased birth weight were the most significant risk factors identified for SG. Although few studies have confirmed effective prevention methods, *Centella asiatica* extract, hyaluronic acid, and daily massages showed some promise. Treatment for general striae has greatly improved over the last few years. Topical tretinoin ≥0.05% has demonstrated up to 47% improvement of SG and non-ablative fractional lasers have consistently demonstrated 50 to 75% improvement in treated lesions of striae distensae.
Conclusion: Overall, SG has seen a resurgence in research over the last few years with promising data being released. Results of recent studies provide dermatologists with new options for the many women who are affected by these disfiguring marks of pregnancy.

Introduction

Striae gravidarum (SG) is a common, disfiguring, gestational change that affects between 55% (Chang et al., 2004; Picard et al., 2015) and 90% (Fitzpatrick and Freedberg, 2003) of women (Ghasemi et al., 2007; Rathore et al., 2011). SG presents as atrophic linear scars and can cause distress, often leading to a decrease in quality of life (Korgavkar and Wang, 2015; Park and Murase, 2013). SG are often overlooked as a cosmetic concern, which does not make the patient burden any less. Current research on risk factors, prevention, and management of this condition has been limited or met with little success and/or provided conflicting results (Chang et al., 2004).

Throughout history, stretch marks have always been a source of distress for pregnant women. As early as 16 BC, the poet Ovid alluded to women who would self-abort their pregnancies to avoid stretch marks (Rayor and Batstone, 1995). Ancient Egyptians recorded numerous preparations for the treatment of stretch marks and Soranus and Pliny the Elder in the 1st Century AD endorsed unripe olive oil and sea salt, respectively (Owsei, 1991). Frankincense is one of the most often recommended treatments (NWI Trading Co., 2016). There has been an additional wide range of therapeutics from topical medications to surgical modalities proposed for stretch marks, which reinforces the concern that is associated with this condition.

SG first present as flat, pink-to-red bands (striae rubra or immature striae) that become raised, longer, wider, and violet-red

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Fig. 1. Immature striae (striae rubra) on the abdomen.

(Figs. 1 and 2). Over a period of months to years, the marks fade and become hypopigmented (striae alba or mature striae), appearing parallel to skin tension lines as scar-like, wrinkled, white, and atrophic marks (Fig. 3; Salter and Kimball, 2006; Sodhi and Sausker, 1988; Watson et al., 1998). SG can cause itching, burning, and discomfort and typically present on the breasts, abdomen, hips, and thighs. Up to 90% of SG appear in primigravidas (Chang et al., 2004). Onset has typically been reported in the late second and early third trimester; however, one study has demonstrated that 43% of women develop SG prior to 24 weeks of gestation (Chang et al., 2004).

The etiopathogenesis involves a combination of genetic factors (Di Lernia et al., 2001), hormonal factors (Chang et al., 2004; Cordeiro et al., 2010; Lurie et al., 2011; Murphy et al., 1992), and increased mechanic stress on connective tissue (Fitzpatrick and Wolff, 2008; Ghasemi et al., 2007; Murphy et al., 1992; Watson et al., 1998). Interestingly, skin stretch has been a controversial trigger as studies have demonstrated an inconsistent association of SG with maternal weight gain and abdominal and hip girth stretch (Atwal et al., 2006; Chang et al., 2004; Poidevin, 1959). With regard to hormonal factors, twice as many estrogen receptors and elevated androgen and glucocorticoid receptors have been observed in striae compared with those in healthy skin (Cordeiro et al., 2010). Pregnancy's distinct hormonal milieu is thought to influence connective tissue that is susceptible to SG when stretched. Ultimately, abnormalities in elastic fibers (Pinkus et al., 1966; Sheu et al., 1991; Tsuji and Sawabe, 1988), collagen fibrils (Pinkus et al., 1966; Shuster, 1979), and other extracellular membrane components (Watson et al., 1998) are believed to underlie the pathogenesis of SG (Wang et al., 2015).

Histologically, the appearance of SG is similar to striae distensae (SD) and contingent on lesion age. Early on, active lesions are comprised predominantly of fine elastic fibers but aging lesions

Fig. 2. Striae rubra on the thigh.

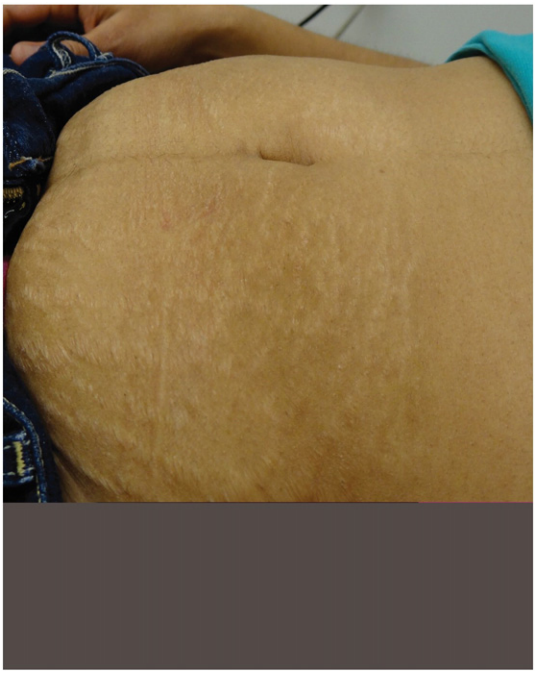

Fig. 3. Mature striae (striae alba) on the abdomen.

demonstrate a thinning of the dermis and decrease of collagen content in the upper dermis (Watson et al., 1998). Biopsy tissue samples of SG show a disorganization, shortening, and thinning of the elastic fiber network compared with tissue samples of normal skin (Murphy et al., 1992; Wang et al., 2015). Although they are thin and disorganized, fibrils are tropoelastin-rich, which is likely due to uncoordinated synthesis (Wang et al., 2015). Light microscopy demonstrates a flattening of the epidermis with atrophy and loss of rete ridges and increased glycosaminoglycans (Murphy et al., 1992; Salter and Kimball, 2006; Watson et al., 1998). However, the severity and development of lesions varies among patients, which indicates a variable genetic predisposition.

Methods

A systematic literature search was conducted using textbooks and PubMed and MEDLINE databases to date to identify evidence-based data on the risk factors, prevention, and management of SG. Key search terms included striae gravidarum, pregnancy stretch marks, and pregnancy stretch. A literature search up to August 2016 revealed 28 articles available online that specifically studied SG, including cross-sectional, prospective, randomized controlled, and quasi-randomized controlled studies. The search was restricted to English-language articles with the exception of two articles that were translated from German. Table 1 provides a summary of studies that assessed risk factors of SG. Table 2 includes studies that assessed SG prevention methods. Table 3 shows studies that are relevant to SG treatments and treatment efficacy and their adverse events. In addition to the limited number of studies on the management of SG (Table 3), we incorporated a review of the most current treatments in use for nongestational SD, which may be used as a guide for future SG treatment.

Results

Risk factors

The most common risk factors for SG include younger age, maternal and family history of SG, higher pre-pregnancy and pre-delivery weight, and higher birth weight (Table 1). Most studies showed a

Table 1
Risk factors for striae gravidarum

Investigators and Study Type	Number of Subjects and Subject profiles	Risk Factors Identified*	Treatments
Picard et al., 2015 Cross-sectional study	800 primiparous ♀ examined postpartum with mean age of 26.3	▪ Younger age ▪ Higher pre-pregnancy weight ▪ Body mass index ▪ Higher weight at delivery ▪ Higher gestational weight gain ▪ Fitzpatrick skin types I and IV ▪ Absence of employment ▪ Family history of striae gravidarum	Topical treatments to reduce the occurrence of SG were not found to be effective
Kasielska-Trojan et al., 2015 Cross-sectional study	299 Caucasian ♀ up to 6 mos after delivery, without distinguishing primiparous or multiparas.	▪ Previous history of SG ▪ Family history of SG ▪ Higher BMI before pregnancy ▪ Lack of chronic diseases ▪ Higher birthweight ▪ SD on the breasts increased risk (71.4% with striae on breasts vs. 28.6% without) ▪ SD on thighs decreased risk (23% with striae vs. 77% without striae)	Progesterone treatment was not found to be related to SG
J-Orh et al., 2008 Cross-sectional study	280 Thai ♀ who had just given birth to first child, in the immediate postpartum period.	▪ Younger age (22.8 yr vs. 26.6 yr) ▪ Higher pre-pregnancy BMI (21.2 kg/m2 vs. 19.8 kg/m^2) ▪ Higher maternal BMI at pregnancy (27.3 kg/m2 vs. 25.6 kg/m^2) ▪ Higher gestational age at delivery (39.1 wk vs. 38.6 wk) ▪ Higher birth weight of baby (3,078.8 g vs. 2,895.8) ▪ Alcohol drinker (91.4% vs. 8.6%) ▪ Had little water intake (7.4 glasses vs. 8.3 glasses) ▪ Family history of SG (82.8% vs. 17.2%)	Did not assess
Osman et al., 2007 Cross-sectional study	112 primiparous Lebanese ♀ assessed during the immediate postpartum period	▪ Younger age (26.5 yr vs. 30.5) ▪ Increased weight gain during pregnancy (15.6 kg vs. 38.4 kg) ▪ Birth weight, gestational age at delivery, and family history of SG associated with moderate-to-severe SG	Did not assess
Atwal et al., 2006 Cross-sectional study with questionnaire	309 primiparous ♀ within 48 hours of delivery	▪ Most significant was low maternal age ▪ 20% (14 of 71) of teenagers had severe striae, not seen in ♀ over 30 yr of age. ▪ Pre-pregnancy BMI greater than 26 ▪ Maternal weight gain of more than 15 kg ▪ High neonatal birth weight	Did not assess
Chang et al., 2004 Cross-sectional study with anonymous survey	161 ♀ who had just given birth	▪ Most significant was a history of breast or thigh striae (81% who developed SG had striae history vs. 31% without SG who had history of striae) ▪ Having a mother with SG ▪ Additional family history (sisters, daughters, grandmothers, aunts, cousins) of SG ▪ Non-white ♀ had higher association with SG (odds ratio = 4.2, 95% CI 1.9, 9.6). ▪ Pre-pregnancy BMI not significantly different	Did not assess
Ersoy et al., 2016 Prospective observational study	211 singleton primiparous pregnant ♀ who were hospitalized for birth and who did not have systemic diseases or other risk factors, like drug use or polyhydramnios.	▪ Younger age ▪ Higher pre-conceptional BMI ▪ Family history ▪ Having a male baby ▪ Lower educational level ▪ Smoking status, skin type, water intake, and level of financial income did not significantly predict SG	Use of preventive oil or drugs, did not affect development of SG
Findik et al., 2011 Prospective study	69 primigravidas using prophylactic iron and vitamin preparations at 36 wks gestation or greater	▪ Family history ▪ Reduced blood vitamin C levels ▪ No significant relation with age, weight gain during pregnancy, abdominal/thigh circumference, or smoking status	Did not assess
Thomas and Liston, 2004 Prospective observational study	128 primigravid ♀ who presented in labor or for induction of labor	▪ Younger age ▪ Higher pre-delivery BMI ▪ Higher baby weight	Did not assess
Davey, 1972	76 primiparous ♀	▪ Younger age ▪ Higher weight	SG were less common in skin

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Table 1 *(continued)*

Investigators and Study Type	Number of Subjects and Subject profiles	Risk Factors Identified*	Treatments
Prospective study		▪ Higher baby weight	messaged with olive oil
Madlon-Kay, 1993	48 nulliparous ♀ at 34 to 36	▪ Younger age	♀ who used oils
Retrospective cohort study	weeks' estimated gestational age	▪ More likely to receive state medical assistance ▪ More likely to have hip striae ▪ Greater weight gain during pregnancy ▪ Diabetes tests and glycosylated hemoglobin levels were similar in ♀ with and without striae.	or creams formed striae as frequently as those who did not

♀=women; BMI=body-mass index; mos=months; SG=striae gravidarum; yrs=years.
* Statistical significance is defined as $p \leq 0.05$

statistically significant association between these risk factors and SG, although Findik et al. (2011) and Chang et al. (2004) did not confirm pre-pregnancy weight or maternal age as a risk factor. Most studies also demonstrated that a history of striae on the breasts, hips, and thighs was associated with formation of SG; however, a study of 299 Caucasian women showed that although striae on the breasts increased risk of SG, striae on the thighs decreased the risk of SG. The study by Chang et al. (2004) found a higher prevalence of SG in non-white women. With regard to socioeconomic status, multiple studies showed that unemployment, receiving state medical assistance, and lower education level were also associated with SG. However, confounding factors should be considered. Increased alcohol intake, decreased water consumption, decreased blood vitamin C levels, and expecting a male baby were also found to be more common among those women who developed SG in select studies. Even though it has been speculated that diabetes and increased serum glucose levels could play a part in the pathogenesis of SG, the studies included here did not reveal an association with diabetes or glycosylated hemoglobin levels. Studies were limited by study type, size, and patient population.

Prevention

Preventative treatments have met with limited success. Creams that contain *Centella asiatica* extract, especially *Trofolastin* cream, are best supported by data for the prevention or reduction of the severity of SG (Table 2; García Hernández et al., 2013; Mallol et al., 1991). *Centella asiatica* is a medicinal herb that is thought to increase the production of collagen and elastic fibers (García Hernández et al., 2013). Mallol et al. (1991) demonstrated that *Trofolastin* cream with *Centella asiatica* extract, α-tocopherol, and collagen–elastin hydrolysates that is applied daily from gestational week 12 until delivery significantly reduced the incidence of SG compared with placebo. Both Mallol et al. (1991) and García Hernández et al. (2013) found that creams that contained *Centella asiatica* significantly reduced the intensity and/or severity of SG among women who did develop SG. García Hernández et al. (2013) also demonstrated that the severity of previous striae significantly increased in the patient group treated with placebo but did not change in the patient group treated with *Centella* cream.

The application of almond oil, olive oil, or cocoa butter consistently failed to significantly lower the incidence of SG compared with placebo group. Two studies did find that when olive oil or almond oil were applied with a massage daily, they were associated with a lower incidence of SG development. However, these results may reflect the benefits of massage alone (Davey, 1972; Timur Taşhan and Kafkasli, 2012).

Alphastria cream and verum cream, two proprietary creams that contain hyaluronic acid combined with various vitamins and fatty acids, were shown to significantly lower the incidence of SG in two studies (de Buman et al., 1987; Wierrani et al., 1992). Hyaluronic acid, the active ingredient in both creams, is thought to increase resistance to mechanical forces and oppose atrophy through stimulation of fibroblast activity and collagen production (Elsaie et al., 2009; Korgavkar and Wang, 2015). In both studies, the creams were applied through massage during the second trimester, which poses the question of whether the creams were truly beneficial or whether the results reflected the benefits of massage alone.

Management

Although many studies that utilize topical medications or lasers for the treatment of nongestational SD have been performed, only a limited number of these studies focused specifically on SG treatment. Treatment should be instituted during the early stages of SG rather than when striae have matured and permanent changes have occurred. Many homeopathic and alternative therapies, including fruit and vegetable oils that hydrate the skin, are employed but limited by insufficient evidence.

Topical medications

Tretinoin cream and a combination of 20% glycolic acid + 10% ascorbic acid were shown to improve SG in clinical studies (Table 3). Use of tretinoin 0.05% and 0.1% creams on a daily basis for 3 to 7 months consistently resulted in overall global improvement of SG up to 47% (Ash et al., 1998), and decreased in mean length and width up to 20% and 23% respectively (Rangel et al., 2001), of lesions. A study by Pribanich et al. (1994) showed that the minimum effective concentration of tretinoin cream is 0.05%. Twenty percent glycolic acid combined with either 10% ascorbic acid or 0.05% tretinoin improved the appearance of SG although there was no statistically significant difference between the two combinations (Ash et al., 1998). Tretinoin increased elastin content in the papillary and reticular dermis of the lesions but ascorbic acid and untreated areas did not show such improvement. Both treatments increased epidermal thickness and decreased papillary dermal thickness in SG lesions.

Laser treatments

A 1540-nm non-ablative fractional laser demonstrated a statistically-significant clinical improvement in SG that ranged from 1 to 24% and an observable difference at 3 months post-treatment (Malekzad et al., 2014). For nongestational SD, both fractional and non-fractional lasers have been employed with varying efficacies.

Among fractional lasers, both non-ablative Erbium (Er):Glass and ablative carbon dioxide (CO_2) lasers have been studied. An average of 50 to 75% improvement in lesions after 2 to 6 nonablative Er:Glass treatments has been reported (Bak et al., 2009; de Angelis et al., 2011; Tretti Clementoni and Lavagno, 2015). Histologic studies showed an increase in elastic fibers and collagen production. This laser was generally safe and treatments were well-tolerated by

Table 2
Prevention of striae gravidarum

Investigators and Study Type	Number of Subjects and Subject Profiles	Preventive Methods Used	Results of Preventive Methods*
Mallol et al., 1991 Randomized, double-blind, placebo-controlled study	80 pregnant ♀ during their first 12 weeks of a healthy pregnancy	Trofolastin cream with *Centella asiatica* extract, α-tocopherol and collagen–elastin hydrolysates; applied daily from 12th week of pregnancy until delivery	▪ Development of SG: 56% in placebo group vs. 34% in treatment group ▪ Intensity of SG was significantly lower in ♀ treated with cream vs. placebo ▪ In ♀ with history of striae during puberty, cream prevented SG in 89% of cases, whereas all ♀ formed SG in the placebo group
García Hernández et al., 2013 Randomized, double-blind, placebo-controlled study	183 pregnant patients over age 18 at week 12 +/- 2	Cream containing hydroxyprolisilane-C, rosehip oil, Centella asiatica triterpenes and vitamin E; applied twice a day around 12 weeks of pregnancy	▪ Effective in preventing SG only in ♀ without a history of striae (6% developed SG on treatment vs. 35% on placebo) ▪ Severity of previous stretch marks increased in the control group during the study, but not in the treated group ▪ Among ♀ who developed new SG, there was increased severity in control vs. treated group
Taavoni et al., 2011 Randomized clinical study	70 nulliparous ♀ aged between 20-30 yrs old, in 18–20th week of gestation with BMI ranging between 18.5-25. 35 used treatment, 35 did not	Olive oil applied topically onto abdomen twice daily, without massaging, vs. no olive oil	▪ SG occurred at the end of the second quarter of pregnancy in 45.7% in intervention group vs. 62.9% in control group ($p = 0.115$) ▪ Difference NOT statistically significant
Soltanipoor et al., 2012 Randomized controlled clinical study	100 nulliparous pregnant ♀; 50 used treatment, 50 did not	Olive oil applied topically onto abdomen twice daily, without massaging, vs. no olive oil	▪ Frequency of severe SG was lower in group that used olive oil. ▪ Difference NOT statistically significant
de Buman et al., 1987 Randomized controlled study	90 pregnant ♀; 30 received treatment cream, 30 received vitamin cream, 30 received placebo	Alphastria cream (hyaluronic acid, allantoin, vitamin A, vitamin E and calcium pantothenate) vs. vitamin cream vs. placebo cream; messaged for a few minutes daily to the thighs, abdomen and chest, starting at the 3rd month of pregnancy and ending 3 mos after childbirth	▪ SG developed in 10% of alphastria treated group vs. 40% of vitamin treated group vs. 37% in placebo treated group
Wierrani et al., 1992 Randomized controlled study	50 pregnant ♀; 24 received treatment, 26 did not receive any treatment	Verum cream (vitamin E, essential fatty acids, panthenol, hyaluronic acid, elastin and menthol); massaged onto the abdomen, thighs and breasts starting at the 20th week of pregnancy	▪ SG developed in 29% of verum treated group vs. 62% in no treatment group
Soltanipour et al., 2014 Parallel randomized controlled clinical study	150 nulliparous ♀ at their second trimester of pregnancy in Iran. 50 subjects in each group	Olive oil vs. Saj® cream that contains lanolin, stearin, triethanolamine, almond oil, and bizovax glycerin amidine vs. placebo	▪ SG occurred in 72% of olive oil group vs. 64% in Saj® cream group vs. 60% in control group. ▪ Differences NOT statistically significant
Osman et al., 2008 Randomized double-blind placebo-controlled study	175 nulliparous ♀ in Lebanon with singleton pregnancies between week 12 and 18 weeks of gestation. 91 with study treatment, 84 with placebo	Cocoa butter lotion vs. placebo lotion, daily from weeks 12-18	▪ SG developed in 45% of patients using cocoa butter cream vs. 48% using placebo ▪ Difference NOT statistically significant
Buchanan et al., 2010 Randomized, double-blind, placebo-controlled study	300 pregnant ♀; 150 received treatment, 150 placebo	Cocoa butter lotion vs. placebo lotion, daily from 16 weeks to delivery	▪ SG developed in 44% of patients using cocoa butter cream vs. 55% using placebo ▪ Difference NOT statistically significant
Timur Taşhan and Kafkasli, 2012 Posttest-only quasi-experimental design with a control group	141 primiparous ♀ who visited the pregnancy unit in Turkey between February 1st, 2010 and April 15th, 2011. 47 subjects in oil + massage, 48 in oil – massage, 46 in control	Bitter almond oil applied with or without massage vs. control; applied every other day in weeks 19–32 of pregnancy, followed by daily until delivery	▪ Frequency of SG: 20% among ♀ who applied oil with massage vs. 38.8% among those who applied w/o massage vs. 41.2% in control group

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Table 2 *(continued)*

Investigators and Study Type	Number of Subjects and Subject Profiles	Preventive Methods Used	Results of Preventive Methods*
Poidevin, 1959 Prospective study	116 primigravidas; ♀ 55 used treatment, 66 did not	Olive oil vs. no olive oil applied daily	▪ SG developed in 68% of olive oil group vs. 55% not using olive oil. ▪ Difference NOT statistically significant
Davey, 1972 Prospective study	76 primiparous ♀; 35 used treatment, 41 did not	Olive oil massaged into abdomen daily vs. no olive oil	▪ The prophylactic use of olive oil to massage the abdomen was associated with a lower incidence of SG

♀=women; BMI=body-mass index; mos=months; SG=striae gravidarum; yrs=years.
* Statistical significance is defined as $p \leq 0.05$

patients. In a study by Lee et al. (2010), ablative CO_2 lasers were demonstrated to have improvements of 50 to 75%, especially in striae alba. However, other studies have shown inconsistent results (Cho et al., 2010). CO_2 lasers are more painful and may have longer recovery times than non-ablative lasers.

Among non-fractional lasers, excimer, pulsed dye, neodymium-doped yttrium aluminum garnet (Nd:YAG), copper bromide, and diode have been studied in the treatment of patients with nongestational SD. The excimer 308-nm laser is used to treat mature striae alba by producing repigmentation and has achieved up to 75% increase in pigmentation; however, results are generally temporary and pigmentation of the normal surrounding skin is an unfavorable consequence (Goldberg et al., 2003). Pulsed dye laser results in textural improvements but has shown a limited benefit to treat striae alba (McDaniel et al., 1996). It may be beneficial in striae rubra by reducing erythema (Aldahan et al., 2016). Nd:YAG laser, also a vascular laser, demonstrated excellent improvement of up to 70% or more, even though it is specifically for immature striae rubra (Goldman et al., 2008). Thirteen of 15 women experienced a complete resolution or modest improvement of striae for up to 2 years in a small study that used copper bromide laser (Longo et al., 2003). The diode laser was used to treat SD in dark-skinned individuals but this laser was ineffective and 64% of patients developed undesirable hyperpigmentation (Tay et al., 2006).

Light treatments

Light therapy modalities such as intense pulsed light (IPL), ultraviolet (UV) light, and infrared light have been employed for the treatment of nongestational SD. IPL seems to result in at least moderate improvement of striae (Al-Dhalimi and Abo Nasyria, 2013), but persistent erythema and post-inflammatory hyperpigmentation may complicate this treatment. UV light, especially a combination of UV-B and UV-A, has been shown to consistently repigment striae alba. However, the results are not permanent and maintenance treatment is required (Sadick et al., 2007). Infrared light at 800 to 1800 nm can result in 25 to 50% improvement in striae alba after only four treatment sessions (Trelles et al., 2008). Long-term studies with larger sample sizes are needed to confirm these results.

Other modalities

Bipolar radiofrequency demonstrated clinical and histologic improvements in SD (Montesi et al., 2007), while tripolar third generation radiofrequency (Tripollar) resulted in 25 to 75% improvement at 1 week post-final treatment (Manuskiatti et al., 2009). Modalities such as microdermabrasion and microneedling have been found to be effective to improve nongestational striae in multiple studies. Microdermabrasion has been especially effective for striae rubra (Abdel-Latif and Elbendary, 2008). Microdermabrasion involves the blowing and subsequent vacuuming of abrasive substances to a treated area. Another study found that although microdermabrasion with sonophoresis improved striae, needling therapy yielded an even greater, statistically-significant improvement in striae compared with microdermabrasion (Nassar et al., 2016). Needling therapy causes controlled skin injury with the goal of producing new collagen and elastin in the papillary dermis.

Discussion

Stretch marks of pregnancy, which most commonly occur on the abdomen, breasts, hips, and thighs, have notably been a cause of distress and concern for the patient. Although many attempts have been made to identify risk factors, prevention methods, and treatments, a limited number of well-conducted, randomized controlled studies exist to date. This systematic review found that more studies addressed risk factors and prevention methods for SG than they did treatments specifically for SG and many more studies evaluated treatments for nongestational SD.

The most significant risk factors identified in this review are younger age, maternal and family history of SG, increased pre-pregnancy and pre-delivery weight, and increased birth weight. For prevention of SG, creams with *Centella asiatica* extract such as Trofolastin cream and a daily massage seem the most supported treatment options by the literature, but further studies are necessary. This information can be helpful for future expectant mothers who would like to try preventative treatments for SG. With regard to the management of SG, the current most effective therapies include tretinoin cream ≥ 0.05% and modalities such as nonablative fractional lasers. Laser treatment appears to yield on average greater mean improvement and in a much shorter time than topical treatments, but no head-to-head studies have been conducted to date. Tretinoin cream and laser treatments resulted in increased elastin content and collagen production in the treated lesions, which can partly explain the improvement observed. Many new studies that test novel laser treatments, microdermabrasion, and microneedling are underway.

Study limitations may explain the conflicting results in some studies. For example, some studies observed pre-pregnancy weight as a significant risk factor (Picard et al., 2015), but other studies did not view this but rather a genetic component as the most significant risk factor (Chang et al., 2004). The available studies often include a small and non-randomized sample size, especially those studies that are relevant to treatment. Additionally, studies do not always indicate the types of striae that are treated. Many more studies have been conducted for nongestational SD, which brings up the concern of whether these results may be extrapolated to SG.

SG are commonly regarded as a cosmetic nuisance and overlooked by practitioners as clinically insignificant. Skindex-29 is a validated questionnaire on the quality of life of patients with dermatologic conditions that has been used to assess total impairment caused by SG. The questionnaire focuses on three scales: emotion (psychological effects), symptoms, and daily functioning. In a study by Yamaguchi et al. (2012) to evaluate the quality of life of women

Table 3
Treatment of striae gravidarum

Investigators and Study Type	Number of Subjects and Subject Profiles	Type of Striae	Treatment	Efficacy*	Adverse Effects
Malekzad et al., 2014 Prospective pilot study	10 ♀ aged 26-50, Fitzpatrick skin types III-V	Striae alba	1540-nm non-ablative fractional laser	▪ Clinical improvement in striae ranging from 1-24% ▪ Improvement between the 4-week treatment and the 16-week treatment was identified ▪ 3 mos after final treatment, patients had observable improvement in the striae, compared with baseline	Mild post-inflammatory hyperpigmentation in one patient after 8-week treatment and mild acne in another patient after 4 weeks of treatment
Rangel et al., 2001 Open-label, multicenter, prospective study	26 ♀ with abdominal pregnancy-related striae	Not reported	0.1% tretinoin cream daily for 3 mos applied to SG	▪ At treatment conclusion, global improvement was achieved from baseline in all stretch marks ▪ Pre-selected target lesion decreased in length by 20% and width by 23%	Erythema and scaling were the most common adverse events
Pribanich et al., 1994 Double-blind placebo controlled study	11 non-pregnant ♀ who had SG, 6 received treatment and 5 placebo	Not reported	0.025% tretinoin cream applied daily for 7 mos	▪ No statistically significant difference in treated group compared to control group	Did not assess
Kang et al., 1996 Double-blind, randomized, vehicle-controlled study	22 healthy white ♀ with erythematous stretch marks, 10 received treatment and 12 vehicle	Striae rubra	0.1% tretinoin (n = 10) or vehicle (n = 12) daily for 6 mos to the affected areas	▪ At 2 mos, tretinoin patients had significant improvements in severity scores of SG vs. vehicle patients ▪ At 6 mos, 80% of tretinoin patients had improvement vs. 8% of vehicle patients ▪ Targeted stretch marks treated with tretinoin had decrease in mean length and width of 14% and 8%, respectively, vs. an increase of 10% and 24%, respectively, in vehicle patients	Erythema and scaling, with itching and burning
Ash et al., 1998 Randomized controlled study	10 American nonpregnant ♀ of varying skin types, age 23 to 49 yr. Striae age ranged from 8 mos to 31 yr and all were white striae. All patients had abdominal striae, 50% also had striae on thighs	Striae alba	20% glycolic acid + 0.05% tretinoin vs. 20% glycolic acid + 10% ascorbic acid, applied daily to abdomen or thighs for 12 weeks (each regimen was applied to half the treatment area)	▪ At treatment conclusion, 47% improvement with 0.05% tretinoin vs. 43% improvement with ascorbic acid ▪ Results not statistically significant from each other, but significant for both compared to pretreatment ▪ 0.05% tretinoin increased elastin content at sites vs. untreated striae by 22% in the papillary and reticular dermis combined ▪ 10% L-ascorbic acid failed to improve elastin content in either the papillary or reticular dermis ▪ Both regimens increased epidermal thickness and decreased papillary dermal thickness	70% of patients experienced mild irritation at treatment initiation on both treatment sites. A single patient developed a mild irritant dermatitis

♀=women; mos=months; SG=striae gravidarum; yrs=years.
* Statistical significance is defined as $p \leq 0.05$

with SG through the Skindex-29 questionnaire, the authors observed significantly greater psychological and/or emotional impairment among pregnant women with SG compared with women without SG (Yamaguchi et al., 2012). Using the same questionnaire, they also noted that pregnant women with severe SG scored significantly higher in areas of psychological and/or emotional impairment as well as daily functioning impairment, compared with those without SG and those with mild SG.

Conclusion

Striae gravidarum are a common form of gestational change that can be a substantial source of distress. Despite the identification of risk factors, prevention of SG remains challenging. Various therapies have been used to improve the appearance of SG. Fractional lasers and topical medications have yielded promising results. Further results from large, randomized-controlled studies are required to validate prevention and treatment options and their long-term efficacy data.

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