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Platelet-rich plasma for striae distensae: What do we know about processed autologous blood contents for treating skin stretchmarks?—A systematic review

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Abstract

Striae distensae, also known as stretch marks, particularly associated with female sex, pregnancy, obesity, and/or hormonal change, are linear bands of benign dermal lesions. Although not posing any health risk, aesthetically unpleasing stretch marks can cause significant psychological distress among those affected. In abundance of therapeutic approaches, some literature sources proclaim platelet-rich plasma to be a promising treatment modality for striae distensae. We aimed to shed some light on the current literature evidence of platelet-rich plasma for treating stretch marks and performed an English literature analysis with two independent reviewers in accordance with PRISMA guidelines searching the PubMed and Web of Science databases in June 2019. Of the 12 found studies, 6 matched inclusion criteria. With no control groups in two, just two other reports used intraindividual comparisons, and all but one publication performed histopathological assessments. All studies observed clinical and subjective improvements without using validated scores or patient-reported outcome measures (PROMs). The main findings were that multiple treatments with platelet-rich plasma demonstrated increased epidermal thickness, rete ridges formation, and collagen/elastin formation, while decreasing the inflammatory cell infiltrate. The current literature evidence supporting the use of platelet-rich plasma for striae distensae is poor. We propose in this review an outline for a study protocol with intraindividual control groups, standardised scores, validated PROMs, and participant incentives to enhance the scientific power in future clinical trials.

KEYWORDS

autologous blood, platelet-rich plasma, PRP, stretchmarks, striae distensae

1 | INTRODUCTION

Stretch marks ("striae distensae", SD) are benign dermal lesions that histologically resemble dermal scars.[1] Clinically and histopathologically two types of striae, distinct by their stage of maturation, exist: "striae rubrae" (SR), appearing initially as immature, tense, erythematous lesions, and later on "striae albae" (SA) with an appearance similar to dermal scars with atrophic, hypopigmented characteristics.[2,3] Histopathologically, SR show reorganisation and reduction of elastin and fibrillin fibres and structural changes of collagen. SA demonstrate epidermal atrophy and loss of rete ridges as well as densely packed eosinophilic collagen bundles arranged parallel to the surface of the skin, similar to dermal scars, in histological examination.[4] Skin with SD shows less elasticity and a rougher surface compared with normal skin.[2]

SD primarily occur due to stretching/tensile forces on the skin during pregnancy, rapid weight gain or fast growth episodes in adolescence. Body areas concerned are predominantly the breasts, abdomen, buttocks and thighs.[4] Other causes include hormonal change,[5] as well as long-term systemic or topical steroid use, Marfan's syndrome, and Cushing disease.[6] SD are a benign, yet aesthetically unpleasing condition for those affected, who suffer from psychological stress related to public exposure of affected body parts (eg, during summer, in public baths). The majority of proclaimed treatment approaches for SD aimed at reducing erythema, inducing collagen stimulation and/or increasing pigmentation with variable success rates, and lack of adequately powered scientific evidence.[7] Treatment modalities with highest level of evidence include topical agents such as retinoic acid or hyaluronic acid, fractional and diode lasers, and radiofrequency (LOE 1). Another promising approach is the treatment with platelet-rich plasma (PRP).[7] Clinical trials on PRP and its effect on striae distensae are scarce and their level of evidence mostly poor. The centrifuged autologous blood derivative contains and releases growth factors, cytokines and peptides, which stimulate wound healing and tissue regeneration.[8] PRP has shown to induce increased expression of type I collagen, elastin, and matrix metalloproteinases such as MMP-1 and MMP-2. Thereby, it has potential to accelerate wound healing.[9] Current data further suggest that PRP may improve early scar quality. It also appears to enhance the quality of atrophic acne scars treated with ablative fractional CO2 laser.[10] Controlled studies have described that PRP combined with traditional therapies and procedures can help minimising acne scars and facial burns, improve aesthetic results, and decrease recovery time.[11] Data for these indications are lacking and study designs are mostly of poor quality. This review serves to investigate the published literature on PRP for treating skin stretchmarks and to provide an outline for a study protocol in order to enhance the scientific power in future clinical trials.

Key Messages

- Stretch marks, also known as striae distensae, are benign dermal lesions, similar to dermal scars, which do not pose any health risk, but are aesthetically unpleasing and can cause significant psychological distress among those affected.
- Platelet-rich-plasma (PRP) is claimed to be a promising treatment modality for striae distensae in some literature sources.
- Main findings of this literature review were that multiple treatments with PRP demonstrated increased epidermal thickness, rete ridges formation, and collagen/elastin formation, while decreasing the inflammatory cell infiltrate.
- In this review we propose an outline for a study protocol with intraindividual control groups, standardised scores, validated patient-reported outcome measures (PROMs), and participant incentives to enhance the scientific power in future clinical trials

2 | MATERIALS AND METHODS

A systematic literature review has been performed by two independent reviewers according to PRISMA guidelines[12] using the databases PubMed and Medline and Web of Science. The following search string was used: [("stretch marks" OR "striae distensae") AND ("platelet rich plasma" OR "prp")].

A total of 12 articles were found. Only original research articles in English were included in the literature review. Articles not matching the criteria "PRP as treatment in stretch marks," containing repeated data or no protocol data at all, were excluded. Finally, six articles were included in the review (Table 1).

3 | RESULTS

Detailed analysis for the included reports can be found in Tables 2-5.

3.1 | Nonrandomised controlled trials

Ibrahim et al treated 68 patients with SD (both rubrae and albae) with skin types III and IV (Fitzpatrick).[13] Lesions were randomised to treatment with either intradermal application of PRP (group I), microdermabrasion (group II), or both microdermabrasion and intradermal injection of PRP (group III). Treatments were performed every 2 weeks for a maximum of six sessions (or until patients' satisfaction). Subjective analysis by evaluating patients' satisfaction as well as objective analysis by two blinded dermatologists evaluating photographs from stretch marks before and after treatment was performed through quartile grading scales: worsening of the striae distensae, no improvement of striae distensae, mild improvement (<25%), moderate improvement (25 to <50%.), marked improvement (50 to <75%), and excellent improvement (≥75%). The quartile grading scale for patients' satisfaction was defined as follows: not satisfied (<25%), slightly satisfied (25 to <50%), satisfied (50 to <75%), or very satisfied (≥75%). Side effects were pain during injection and ecchymosis. Three patients in the PRP group showed worsening of the striae, which the authors commented to be "due to maintenance of the cause of the striae ('physical exercise') and not a consequence of the treatment with PRP". Histopathological examinations were performed in nine patients (three in each group) before and 3 months after treatment. Results showed that both subjectively and objectively there was significant improvement of the appearance of stretch marks treated with PRP or both PRP and microdermabrasion compared to those treated with microdermabrasion only. Histopathologically improvement of epidermal atrophy, increase in epidermal thickness, and increase in rete ridges formation with decrease in perivascular inflammatory infiltrate were seen after PRP. Elastic fibres increased in number became thicker, longer and evenly arranged. Histological differences between groups were not further discussed.[13]

Ahmed and Mostafa included 45 patients with skin types III and IV (Fitzpatrick) with both striae albae and rubrae.[14] They grouped evenly with 10 striae albae and 5 striae rubrae per group (15 patients each). Group A was treated with carboxytherapy (intradermal application of CO_2), group B received intradermal application of PRP, and group C tripolar radiofrequency (RF). All treatments were performed every week for a total of 5 sessions. Photographs were taken before and 1 month after treatment. Imaging was evaluated by two blinded dermatologists by measuring the width of the largest striae before and after treatment (mild improvement <25%, moderate improvement = 26% to 50%, marked improvement = 51% to 75%, excellent improvement = 76% to 100%). Patients' satisfaction was graded as follows: "unsatisfied", "slightly satisfied", "satisfied", or "very satisfied". Punch biopsies were taken from three patients (one per group) before and after treatment. In this study, the group treated with PRP showed significantly less patients' satisfaction than groups

TABLE 1 Flowchart of study selection according to PRISMA guidelines

Identification	• Records prior to 06/20 19 identified via a PubMed search (n = 12) • ("striae distensae" OR "stretch marks") AND ("platelet rich plasma" OR "prp")
⇓	
Screening	• Records screened on title and abstract (n = 12) • Records excluded: letter to the editor, reviews with topics other than PRP (n = 3)
⇓	
Eligibility	• Full-text articles assessed for eligibility (n = 9) • Full-text articles excluded: data repeated in other study, no protocol data (n = 3)
⇓	
Included	• Studies included in synthesis (n = 6)

TABLE 2 Study design summary of included reports

Study	No. of patients	Groups	PRP treated	Control	Skin type (Fitzpatrick)	No. of treatments	Interval (weeks)
Ibrahim et al	68	3 (I, II, III)	34 (I,III)	Interindividually	III, IV	6 (max.)	2
Ahmed and Mostafa	45	3 (A, B, C)	15 (B)	Interindividually	III, IV	5	1
Hodeib et al	20	2 (A, B)	20 (A)	Intraindividually	III, IV	4	3 to 4
Gamil et al	30	2 (PRP, tretinoin)	30 (PRP)	Intraindividually	III, IV, V	3	4
Kim	19	1	19	No	IV	3	4
Suh	18	1	18	No	III, IV, V	4	2

TABLE 3 Outcome measures of included studies

Study	Histology[a]	Patients' satisfaction	Stretchmark assessment scale	2D photo	Blinded evaluators	Quartile grading scale	Clinical evaluation (stretchmark)	Side effects PRP
Ibrahim et al	Yes	Yes	No	Yes	2	Yes	No	I (n = 23): pain (n = 7, 30.4%); ecchymosis (n = 5, 21.7%) worsening (n = 3, 13%)III (n = 11): pain (n = 8, 72.73%) ecchymosis (n = 2, 18,2%)
Ahmed and Mostafa	Yes	Yes	No	Yes	2	Yes	Yes	B (n = 15): pain (n = 4, 26,67%); ecchymosis (n = 1; 6.67%)
Hodeib et al	Yes	Yes	No	Yes	3	Yes	No	A (n = 20): pain (50%), ecchymosis (40%)
Gamil et al	Yes	Yes	No	Yes	2	No	No	PRP (n = 30): mild pain (n = 27, 90%), mild bruises (n = 2, 6, 7%)
Kim et al	No	Yes	No	Yes	2	Yes	No	Transient bruising (3-7 days) in all patients
Suh et al	Yes	Yes	No	Yes	2	Yes	(Yes)	Post-inflammatory hyperpigmentation (11.1%)

[a]Detailed information about histologies taken (specimens, staining, results, and so on; see Table 4).

TABLE 4 Histology of included studies

Study	Timeline	Number of specimens	Staining	Outcome
Ibrahim et al	Before +3 months after	9 (3 of each group)	H&E, Masson Trichrome, Orcein, Van Grieson	↑: epidermal thickness, rete ridge formation, elastic fibres (thicker, longer, and more evenly arranged) ↓: perivascular infiltrate ("especially" after PRP)
Ahmed and Mostafa	Before +3 months after	3 (albae, different treatments)	H&E, Verhoeff-Van-Giesen, Orcein	↑: epidermal thickness, rete ridge formation, dermal collagen fibres (Van Giesen), elastic fibres (longer, thicker, and evenly arranged) (Orcein) ↓: oedema (dermis)
Hodeib et al	Before +3 months after	20	H&E, fibronectin (immunohistochemistry)	Significantly higher expression of fibronectin in group B
Gamil et al	Before +2 months after	"Selected" patients	H&E, Masson Trichrome, Van Grieson	↑: collagen bundles, elastic fibres in both groups
Kim et al	—	—	—	—
Suh et al	Before +2 months after	3	H&E, Victoria Blue	↑: collagen + elastic fibres, subepidermal collagen density

TABLE 5 PRP preparation techniques of included studies

Study	System used	Amount of venous blood	Centrifugation steps	Centrifugation settings (step I)	Centrifugation settings (step II)	Additional preparation step	Amount of PRP
Ibrahim et al	n/a	20 cc	2	1419 g for 7 min (soft spin)	2522 g for 5 min (hard spin)	None	2 cc
Ahmed et al	n/a	10-20 cc	2	1409 g for 7 min (soft spin)	2504 g for 5 min (hard spin)	None	1-2 cc
Hodeib et al	n/a	10-20 cc	2	1409 g for 7 min (soft spin)	2504 g for 5 min (hard spin)	None	1-2 cc
Gamil et al	n/a	10 cc	2	150-200 g for 10 min (soft spin	1500 to 2000 g for 15 min (hard spin)	None	2 cc
Kim et al	MyCells; Estar Technologies Ltd, Holon, Israel	n/a	1	1200 g for 7 min	n/a	PRP filtering using system's sleeve filter	n/a
Suh et al	n/a	12 cc	2	1200 g for 15 min	1800 g for 10 min	none	n/a

TABLE 6 Proposal for future clinical study design using platelet-rich plasma (PRP)

Proposal for future clinical study design using platelet-rich plasma (PRP)
Prefer striae albae over striae rubrae (only one subset of stretch marks, since striae albae and striae rubrae have distinct histopathological features and must not be grouped accordingly)
Choice of adequate control group (untreated areas with comparable exertion of tensile forces as on the treated site, for example, contralateral side on the trunk)
Use intraindividual comparison to remove interindividual bias
Standardise the preparation protocol for PRP and perform a full blood count with one small vial of blood (dose-dependent effect?)
Standardise the repetition intervals in case of multiple treatment sessions
Histopathological assessments must always include untreated controls vs treated areas in the same individual
Define a primary endpoint to facilitate evaluation of the study (eg, histopathological examination)
Use already established patient-reported outcome measures (PROMs) specifically designed for stretch marks (eg, subset of Body-Q) to evaluate subjective patient satisfaction

FIGURE 1 Proposed intraindividual study design for future clinical trials with consideration of full blood count and another treatment modality

treated with carboxytherapy or RF. Clinical improvement was shown in all three groups (not significant). Analysis of different anatomical regions demonstrated that PRP

(group B) had significant improvements of texture at the trunk, compared with the (upper or lower) limbs, but no other statistically significant differences were found. Side effects from PRP were pain during injection and ecchymosis. Histopathological findings from striae albae 3 months after treatment with PRP demonstrated an increase in epidermal thickening with formation of *rete ridges* and decrease in perivascular infiltrate. Additionally, an increased number of collagen fibres and decreased oedema between fibres was detected as well as increase of elastic fibres, which were longer, thicker, and more evenly arranged. Histological changes were similar in all three groups and there was no significant difference among them.[14]

Hodeib et al investigated 20 patients presenting with striae albae in skin types III and IV (Fitzpatrick) comparing intraindividually PRP injections on the right side of participants' abdomen (group A) as well as carboxytherapy on their left (group B). Treatments were repeated every 3–4 weeks for 4 sessions in total. Punch biopsies were taken for histological assessment before and 3 months after treatment (H&E and fibronectin immunohistochemistry). Photographs were also taken before and 3 months after treatment, and evaluated by three blinded dermatologists by a quartile grading scale (subjective observer assessment): mild improvement: 0% to 25%, moderate improvement: 26% to 50%, marked improvement: 51% to 75%, excellent improvement: 76% to 100%. Patients' satisfaction was also polled and recorded as "unsatisfied", "slightly satisfied", "satisfied", or "very satisfied". Results showed significant improvement in striae albae after treatment in both groups, with no statistically relevant difference between the groups for any parameter. Side effects after PRP were pain during injection in 50% of the patients and ecchymosis in 40%. Immunohistochemistry showed a statistically significant higher expression of fibronectin in group B as compared with group A.[6]

Gamil et al compared treatment with intradermal application of PRP and topical 0.05% tretinoin cream in 30 patients with skin types III, IV, and V (Fitzpatrick) with striae albae and/or rubrae. Left-sided and right-sided striae were randomly assigned to treatment with either PRP or topical tretinoin cream. Intradermal PRP injection was performed every month for a total of three sessions. Topical tretinoin cream was applied every night for a total of 3 months. Additionally, a topical antibiotic was applied for 3 days after each treatment session. Clinical improvement was measured by two blinded dermatologists evaluating photographs before and after treatment, categorising results as "perfect", "satisfactory", and "unsatisfactory". Patients were asked to rate their personal satisfaction as "poor", "good", "very good", or "excellent". Both subjective evaluations (observer and patient) were significantly higher for the striae albae treated with PRP than the tretinoin-treated ones. However, no improvement was seen for both groups in striae rubrae. Side effects with PRP during treatment were pain during injection in 90% of the patients as well as mild bruises in 6.7%. Skin biopsies were taken before and 2 months after the last treatment only in selected patients. Histologically, collagen bundles and elastic fibres were increased, but no further differences were discussed in the report.[15]

3.2 | Observational studies

Kim et al included 19 female Asian patients with skin type IV (Fitzpatrick) in their observational study all treated with intradermal radiofrequency and PRP every 4 weeks for a total of three sessions.[5] PRP was not studied in its effect alone, and no control group was used. The investigators analysed clinical improvement from photographs taken before each session and 1 month after last treatment. The photographs were evaluated by two blinded dermatologists. Investigators also rated clinical improvement subjectively on a quartile grading scale of 0 (no change, 0%), 1 (mild improvement, 0%-25%), 2 (moderate improvement, 25%-50%), 3 (marked improvement, 50%-75%), and 4 (excellent improvement, 75%-100%). Patients rated themselves as either "unsatisfied", "slightly satisfied", "satisfied", or "very satisfied". 63.2% of patients reported they were "satisfied" or "very satisfied". The two observational raters found that just one of the 19 patients (5.3%) showed excellent improvement, 7 (36.8%) demonstrated marked, 6 (31.6%) moderate, and 5 (26.3%) patients only mild improvement. Side effects included transient bruising that lasted 3 to 7 days in all patients. No other evaluations were performed.[5]

Suh et al treated 18 female Asian patients with skin types III to V (Fitzpatrick) presenting with striae albae by plasma fractional ablative RF, acoustic wave pressure ultrasound (two handpieces, Legato System, Alma Lasers, Israel), and PRP injections.[16] The combination was repeated every 2 weeks for a total of four sessions. No control group was used. Clinical improvement of the stretch marks was evaluated by two blinded reviewers rating photographs before and 2 months after last treatment. Rating was performed using a quartile grading scale (mild improvement 1%-24%; good improvement 25%-49%; very good improvement 50%-74%; and excellent improvement 75%-100%). Six of the 18 patients (33%) were rated having excellent results, 7 (38.9%) very good, 4 (22.4%) good results, and one (5.6%) had mild improvement. Patients themselves reported whether they were "not satisfied", "slightly satisfied", "satisfied", "very satisfied", or "extremely satisfied". 72.2% of the participants

claimed to have been either "extremely" or "very satisfied". The only reported side effect was post-inflammatory hyperpigmentation in two patients, which improved within 4 weeks. Skin biopsies of the lesions were taken in three patients before and 2 months after treatment. Histology at baseline showed a decrease in collagen and elastic fibres in the reticular and papillary dermis. Post-treatment specimens showed significant increase of both collagen and elastic fibres in these respective layers of the skin, accompanied by an increased subepidermal collagen density.[16]

4 | DISCUSSION

The main goal of this review was to determine the effectiveness of PRP in treating striae distensae. Six studies were included. The main findings were that multiple (≥3) repeated intradermal PRP injections for stretch marks appear to be a safe treatment modality with only initial minor side effects like transient bruising or pain during injection.[5,6,13-15] The single report describing post-inflammatory hyperpigmentation was most likely a result of the combination of PRP with laser therapy.[16]

Histopathologically intradermal application of PRP resulted in the few selected samples in an increase of collagen, elastic fibres,[14,16] epidermal thickness, increase of rete ridges formation, and reduction of the perivascular infiltrate.[7,8]

Although all but one included report performed histological assessments, only "selected" skin biopsy specimens were taken across the five studies, of which only a few were selected for PRP-treated SD areas. One report failed to mention the amount of punch biopsies taken or even the origin of which specific group (PRP or other),[11] while two other studies used only one biopsy per group.[14,16]

From the included studies, we were unable to scientifically distinguish PRP effects on outcomes as compared with other treatment modalities. Notably, contradictory results for carboxytherapy vs PRP were observed with regard to patient satisfaction, where PRP being either superior or inferior in the comparison.[13-15] Studies with only one group of patients receiving combined treatment modalities alongside PRP made it impossible to distinguish PRP-related effects on treated stretch marks.[5,16]

Only one report distinguished PRP effects on striae albae and rubrae and found that—when extrapolating data from the comparison group with a topical cream—patients' satisfaction and clinical improvement to be superior in striae albae than striae rubrae.[15] Although two other studies used striae rubrae and albae to test their treatment options, none revealed statistically significant differences for outcomes in either, used small sample sizes, incoherent group composition and no randomisation.[13,14]

The subjective evaluation of clinical improvement in most studies by blinded observer-rated 2D photographic material was based on a quartile grading scale,[5,6,13,14,16] but no uniform numerical cut-off was defined on which improvement was based on,[5,6,13,15]: two of the reports[14,16] used the reduction of width as an indicator of improvement. All but one of the included reports used no clinical subjective evaluations, which was also analysed statistically. Ahmed and Mostafa employed scar scale-like clinical features to rate the stretch marks: texture, skin elasticity, horizontal striations, elevation of striae rubra, depth of striae alba, and overall skin improvement.[14] Previous research on scars demonstrated advantages of 3D photographic assessments, making this type of technology an obvious choice for its application for stretchmarks to objectively rate surface area and irregularity, texture, and elevation.

Additional technology also lent from the abundant reports on scar assessments could further improve objective ratings of colour, biomechanical properties, pathophysiological disturbances, tissue microstructure, and sensate perception.[17,18] None of these were used in the investigated studies in this review.

None of the investigated studies used a standardised assessment scale for the subjective evaluation of SD. The type of scoring applied in the five reports was not part of a patient-reported outcome measurement instrument (PROM): five used a "satisfaction score" ("not satisfied", "slightly satisfied", "satisfied" or "very satisfied"),[5,6,13,14,16], and one a "grading score" with one linguistically negative and three positive metrics ("poor", "good", "very good", or "excellent").[15] To all studies' defence, the PROM instrument specifically designed for stretch marks as part of the BODY-Q was only published in the same year as the latest of the included studies.[19]

4.1 | Limitations

In this systematic review included reports could not be compared quantitatively. This was a result from a combination of various factors: lack of adequate control groups, combination of treatment modalities rendering it difficult to extract PRP effects alone, failure of application of a uniform scoring system, variable use of histopathological specimens, and the simultaneous treatment of striae albae and rubrae. One major limitation of all studies was the broad variety of preparational techniques for PRP. Although some used similar protocols, neither used platelet counts, leukocyte counts nor the platelet/leukocyte ratio to control

for differences in patients in any of the evaluated studies. Furthermore, exclusion criteria may have resulted in important studies being missed, for example, when not being published in English language.

4.2 | Outlook

The authors of this review think it is futile to conclude that "further studies are needed" and we therefore suggest a prospective outline applicable to clinical practice with the consideration of possible limitations of our proposal (Figure 1 and Table 6).

Based on investigated studies, no explicit statement for appropriate time intervals between and quantity of PRP treatments can be given. There is also no clear evidence for when to define an endpoint for histopathological examination. Previous reviews on PRP for scars or facial aesthetic indications suggest monthly applications of PRP for at least two sessions. In various studies, significant histological changes were observed after 3 months of repeated applications of PRP compared to baseline.[10,11,20] This is in conjunction with the findings of this literature review (increase of collagen, elastic fibres,[14,16] epidermal thickness, increase of rete ridges formation, and reduction of the perivascular infiltrate.[7,8]

The ideal control group is an SD not treated at the approximate same location with the same submission to tensile forces and serving as control for future analyses including histopathology. This could be the contralateral side when treating, for example, stretchmarks on the trunk region. Regarding recruitment of prospective patients, this is probably a difficult selling point. A possible solution is in the case of offering different treatments (eg, control, PRP + else) to apply the one in the future, which had the best subjective outcome for the patient (customised patient-centred optimal treatment) or even offering one of the repetitive sessions at a significant discount (eg, in the case of when also requiring a biopsy). For PRP preparations, respective blood drawings should include one additional vial for a full blood count, at least to quantify the amount of platelets used for treatment. No dose-dependent effect has so far been mentioned or evaluated in any study.

Histopathological assessments seem even more difficult to propose to prospective recruits, notably in the light of an already impaired appearance of the area with stretch marks. When comparing different repetitive treatments in a single stretch mark, one must pay attention to "hit" the right spot "again" with the same treatment (group adherence), and (nonpermanent) marking (even tattooing) can aid in verification of the concerned areas. A potential workaround for both suggestions is the inclusion of areas, which require future surgical resection, shall the patient collectively allow to plan accordingly (eg, surgical subpopulation). Whether an objective technological assessment shall be proposed for the use in future studies is entirely dependent on the intended observations (primary endpoint?) during a study, the underlying infrastructure and potential investment costs for such a tool (eg, 3D scanners).

5 | CONCLUSIONS

The current literature evidence supporting the use of PRP for SD is poor. We proposed in this review an outline for a study protocol with intraindividual control groups, standardised scores, validated PROMs, and participant incentives to put more scientific power into future clinical trials on PRP for SD.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data openly available in a public repository that issues datasets with DOIs

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REFERENCES

1. Ross NA, Ho D, Fisher J, et al. Striae distensae: preventative and therapeutic modalities to improve aesthetic appearance. *Dermatol Surg*. 2017;43(5):635-648. https://doi.org/10.1097/DSS.0000000000001079.
2. Cho C, Cho E, Kim N, et al. Biophysical properties of striae rubra and striae alba in human skin: comparison with normal skin. *Skin Res Technol*. 2019;25(3):283-288. https://doi.org/10.1111/srt.12645.
3. Elsaie ML, Baumann LS, Elsaaiee LT. Striae Distensae (stretch Marks) and different modalities of therapy: an update. *Dermatol Surg*. 2009;35(4):563-573. https://doi.org/10.1111/j.1524-4725.2009.01094.x.
4. Al-Himdani S, Ud-Din S, Gilmore S, Bayat A. Striae distensae: a comprehensive review and evidence-based evaluation of prophylaxis and treatment. *Br J Dermatol*. 2014;170(3):527-547. https://doi.org/10.1111/bjd.12681.
5. Kim IS, Park KY, Kim BJ, Kim MN, Kim CW, Kim SE. Efficacy of intradermal radiofrequency combined with autologous platelet-rich plasma in striae distensae: a pilot study. *Int J Dermatol*. 2012;51(10):1253-1258. https://doi.org/10.1111/j.1365-4632.2012.05530.x.

6. Hodeib AA, Hassan GFR, Ragab MNM, Hasby EA. Clinical and immunohistochemical comparative study of the efficacy of carboxytherapy versus platelet-rich plasma in treatment of stretch marks. *J Cosmet Dermatol*. 2018;17(6):1008-1015. https://doi.org/10.1111/jocd.12481.
7. Hague A, Bayat A. Therapeutic targets in the management of striae distensae: a systematic review. *J Am Acad Dermatol*. 2017;77(3):559-568.e18. https://doi.org/10.1016/j.jaad.2017.02.048.
8. Samadi P, Sheykhhasan M, Khoshinani HM. The use of platelet-rich plasma in aesthetic and regenerative medicine: a comprehensive review. *Aesthetic Plast Surg*. 2018;43:803-814. https://doi.org/10.1007/s00266-018-1293-9.
9. Cho EB, Park GS, Park SS, et al. Effect of platelet-rich plasma on proliferation and migration in human dermal fibroblasts. *J Cosmet Dermatol*. 2019;18(4):1105-1112. https://doi.org/10.1111/jocd.12780.
10. Alser OH, Goutos I. The evidence behind the use of platelet-rich plasma (PRP) in scar management: a literature review. *Scars Burns Heal*. 2018;4:205951311880877. https://doi.org/10.1177/2059513118808773.
11. Gupta AK, Versteeg SG, Rapaport J, Hausauer AK, Shear NH, Piguet V. The efficacy of platelet-rich plasma in the field of hair restoration and facial aesthetics—a systematic review and meta-analysis. *J Cutan Med Surg*. 2019;23(2):185-203. https://doi.org/10.1177/1203475418818073.
12. Moher D. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Ann Intern Med*. 2009;151(4):264. https://doi.org/10.7326/0003-4819-151-4-200908180-00135.
13. Ibrahim ZAE-S, El-Tatawy RA, El-Samongy MA, Ali DAM. Comparison between the efficacy and safety of platelet-rich plasma vs. microdermabrasion in the treatment of striae distensae: clinical and histopathological study. *J Cosmet Dermatol*. 2015;14(4):336-346. https://doi.org/10.1111/jocd.12160.
14. Ahmed NA, Mostafa OM. Comparative study between: carboxytherapy, platelet-rich plasma, and tripolar radiofrequency, their efficacy and tolerability in striae distensae. *J Cosmet Dermatol*. 2018;18:788-797. https://doi.org/10.1111/jocd.12685.
15. Gamil HD, Ibrahim SA, Ebrahim HM, Albalat W. Platelet-rich plasma versus tretinoin in treatment of striae distensae: a comparative study. *Dermatol Surg*. 2018;44(5):697-704. https://doi.org/10.1097/DSS.0000000000001408.
16. Suh D-H, Lee S-J, Lee J-H, Kim H-J, Shin M-K, Song K-Y. Treatment of striae distensae combined enhanced penetration platelet-rich plasma and ultrasound after plasma fractional radiofrequency. *J Cosmet Laser Ther Off Publ Eur Soc Laser Dermatol*. 2012;14(6):272-276. https://doi.org/10.3109/14764172.2012.738916.
17. Lee KC, Dretzke J, Grover L, Logan A, Moiemen N. A systematic review of objective burn scar measurements. *Burns Trauma*. 2016;4(1):14-33. https://doi.org/10.1186/s41038-016-0036-x.
18. Lumenta DB, Kitzinger H-B, Selig H, Kamolz L-P. Objective quantification of subjective parameters in scars by use of a portable Stereophotographic system. *Ann Plast Surg*. 2011;67(6):641-645. https://doi.org/10.1097/SAP.0b013e3182380877.
19. Poulsen L, Pusic A, Robson S, et al. The BODY-Q stretch Marks scale: a development and validation study. *Aesthet Surg J*. 2018;38:990-997. https://doi.org/10.1093/asj/sjy081.
20. Hesseler MJ, Shyam N. Platelet-rich plasma and its utility in the treatment of acne scars: a systematic review. *J Am Acad Dermatol*. 2019;80(6):1730-1745. https://doi.org/10.1016/j.jaad.2018.11.029.

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