Plasma Skin Resurfacing for Regeneration of Neck, Chest, and Hands: Investigation of a Novel Device

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BACKGROUND Many noninvasive treatments to rejuvenate photodamaged skin are characterized by an unattainable balance between effectiveness and morbidity. The demand for safe, effective procedures has fueled the emergence of plasma skin regeneration (PSR). Preliminary studies have elaborated on the safety and efficacy of PSR for facial skin; however, no evaluation in nonfacial areas has been made.

OBJECTIVE This study was conducted to evaluate the efficacy and safety of PSR in the treatment of moderately photodamaged skin on the neck, chest, and dorsal hands.

MATERIALS AND METHODS Thirty skin areas in 10 patients were selected. Each area received one of three discrete energy settings using a commercially available PSR system. Clinical evaluations of skin texture, pigmentation, wrinkle severity, and side effects were conducted immediately and at 4, 7, 14, 30, and 90 days after treatment.

RESULTS Mean clinical improvements of 57, 48, and 41% were observed in chest, hands, and neck sites, respectively. Significant reduction in wrinkle severity, hyperpigmentation, and increased skin smoothness were achieved. Higher-energy settings yielded greater benefit but also prolonged tissue healing.

CONCLUSIONS PSR offers improvement of moderately photodamaged skin of the neck, chest, and dorsal hands with limited side effects. Further studies are needed to determine the effect of multiple treatment sessions, optimal treatment parameters, and intervals for each site and longevity of clinical results.

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Photodamaged skin occurs as a result of its chronic exposure to ultraviolet (UV) light and is characterized by roughened surface texture, dyspigmentation, telangiectasias, rhytides, and skin laxity. The histologic and clinical changes are manifestations of UV light–generated DNA injury and creation of reactive oxygen species. The impetus for safe and effective therapies is related to the high incidence of cutaneous photodamage in European and North American populations with an abundance of lighter skin phototypes.

Ablative and nonablative lasers have been used successfully over the past decade to improve many of the signs of photodamaged skin.[1,2] Ablative laser treatments, such as carbon dioxide (CO_2) and erbium lasers, have been applied alone or in conjunction with surgical lifting procedures to effectively treat facial skin.[3,4] As a consequence of epidermal removal during these ablative laser skin resurfacing treatments, patients often experience significant morbidity during the reepithelialization process, including marked erythema and edema and risk of bacterial and viral infection, pigmentary alteration, ectropion, and hypertrophic scar formation.[3,5–8] Attempts to apply ablative lasers on nonfacial skin (e.g., neck, chest, dorsal hands) have been limited by significant delays in reepithelialization and greater risk of morbidity due to the limited number of pilosebaceous glands in these areas. In contrast, nonablative laser treatments utilizing far-infrared wavelengths (e.g., 1,320-Nd:YAG, 1,450-nm diode) are capable of creating controlled dermal wounds without epidermal disruption. Although minimal morbidity is encountered, nonablative laser skin treatment often results in reduced clinical efficacy

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with minimal observable improvement of atrophic scars and rhytides.[9–11]

Plasma skin regeneration (PSR) is a novel process that involves the generation of plasma through the use of ionized energy that thermally heats tissue. A pulse of ultrahigh-energy radiofrequency (RF) from the device generator converts nitrogen gas into plasma within the handpiece. The plasma emerges from the distal end of the device handpiece and is directed onto the skin area to be treated. Rapid heating of the skin occurs as the excited gas transfers heat to the skin. Fibroblast activity is increased during dermal regeneration, with the retained necrotic epidermis serving as a biologic dressing for the formation of a new stratum corneum and epidermis. Preliminary clinical studies have shown that the PSR system can effectively treat facial skin with minimal morbidity;[12–15] however, no studies have been published that have specifically evaluated its effects on nonfacial sites. This study was therefore conducted to evaluate the safety and efficacy of PSR in the treatment of moderately photodamaged skin on the neck, chest, and hands.

Materials and Methods

Thirty moderately severe photodamaged skin areas, evenly divided between neck, chest, and dorsal hand sites in 10 patients, were selected for entry in this institutional review board–approved prospective study. The study protocol also conformed to the guidelines of the 1975 Declaration of Helsinki. The study was open to adults of any skin phototype or sex with moderately photodamaged skin on the neck, chest, and/or dorsal hands. Individuals with internal or external cardiac pacemakers or other electronic medical devices, concomitant pregnancy or lactation, prior use of isotretinoin within 6 months of study initiation, keloid scarring tendencies, presence of collagen vascular disorders or other autoimmune disease, history of any skin resurfacing procedure to the treatment areas within the preceding year, or concomitant/ongoing adjunctive skin treatments (chemical peel or other laser therapy) were excluded from study entry. The study group meeting all inclusion criteria consisted of 10 women (47–67 years; mean, 54.4 years; skin phototypes I–IV).

After informed consent had been obtained, the skin areas to be treated were anesthetized with topical anesthetic cream (EMLA, Astra Pharmaceuticals, Westborough, MA) under plastic wrap occlusion for 60 to 90 minutes before treatment. The cream was removed with dry gauze, after which time each area was randomly selected to receive one of three discrete energy settings (1.0, 1.5, or 1.8 J) using a commercially available PSR system (Portrait, Rhytec, Waltham, MA). All treatments were performed on thoroughly dry skin by the same operator (TSA) within 5 minutes of topical anesthetic cream removal. The device handpiece was held approximately 5 mm from the skin surface, and the involved areas were treated with 10% to 20% overlap of pulses in a single pass. Pulse repetition rates of 1 to 4 Hz were used, subject to the discretion of the operator. The essentially instantaneous generation of plasma with controlled application of RF energy produces individual plasma pulses that heat tissue. Adjustment of RF power and pulse width enables control of tissue effects by altering the amount of energy delivered to tissue per pulse. In practice, the energy per pulse is adjustable between 1 and 4 J. The power and duration of each RF pulse are directly proportional to plasma strength. Relatively low energies were selected due to the nonfacial areas under study and their expected slow healing response.

Immediately after treatment, a petrolatum-based ointment (Aquaphor, Beiersdorf Inc., Wilton, CT) was applied to the areas. Patients were instructed to gently cleanse the areas with mild cleanser and water and to reapply the ointment at least three times daily. Nonstick gauze dressings were only used to protect the treated areas from UV light exposure or abrasion due to clothing. Patients were instructed to report any discomfort or concern on the day of surgery and at subsequent follow-up visits.

Standardized digital photographs using identical patient positioning, lighting, and camera settings were obtained of study sites before and immediately after treatment and at Posttreatment Days 4, 7, 14, 30, and 90. Clinical evaluations of skin texture, pigmentation, wrinkle severity, and incidence of side effects were conducted by two independent medical assessors using standardized grading scales[12–15] at each of the follow-up visits. Statistical analyses were performed on all clinical ratings.

Histologic examinations of 3-mm skin punch biopsies obtained from each of the 30 areas before and 90 days after treatment were also performed by a board-certified dermatopathologist blinded to the specifics of the study protocol, so that for each area treated, epidermal architecture and thickness and amount and quality of dermal collagen reformation could be measured. In addition to hematoxylin and eosin stains, picrosirius nonbirefringent stains were performed on the tissue specimens to better demonstrate changes in dermal collagen and elastin.

Results

Mean clinical improvements of 57, 48, and 41% were observed in chest, hands, and neck sites, respectively (Figures 1–3). Significant reduction in wrinkle severity ($p < .001$) and hyperpigmentation ($p < .001$) as well as increased skin smoothness ($p < .05$) measurements were achieved in all areas (Tables 1–3).

Higher-energy settings yielded greater clinical benefit, but also prolonged tissue healing (14 days vs.

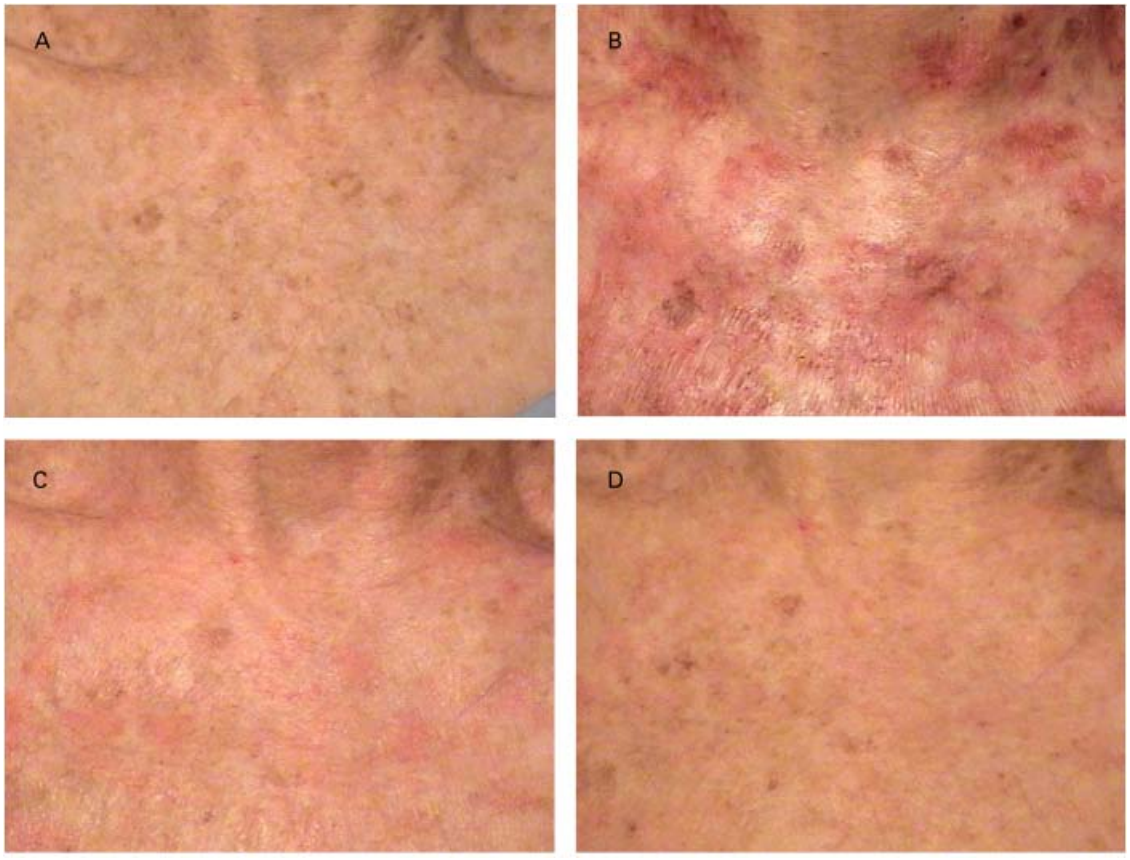

Figure 1. Photodamaged skin on the anterior chest before (A) and 4 days (B), 14 days (C), and 90 days (D) after one PSR treatment. (A and B) Wrinkle grade, 4; pigmentation grade, 2. (C and D) Wrinkle grade, 2; pigment grade, 1.

7 days). Side effects of erythema, edema, and desquamation were uniformly experienced. Epidermal sloughing with clinical evidence of a superficial dermal wound was evident within 48 hours of treatment. No infections were encountered and reepithelialization with normalization of external skin architecture occurred within a few days. Hypopigmentation and scarring were not observed in any patient or body region treated.

Histologic tissue examination revealed flattened rete ridges and clumped elastin in pretreatment specimens. In contrast, epidermal thickening, decreased solar elastosis, and increased amount of new collagen deposition in the upper dermis were seen in all biopsy specimens 90 days after treatment (Figure 4).

Discussion

This study is the first to report the safety and efficacy of PSR in nonfacial skin. The data presented herein support its positive rejuvenative effect as well as its high safety profile in cutaneous sites that have notoriously been difficult to treat with ablative laser technology due in large part to the relative lack of pilosebaceous glands needed to effect rapid reepithelialization in these areas.

Significant clinical improvement of rhytides was observed after a single PSR treatment in all three sites under study, with the chest, hands, and neck exhibiting improvements of 57, 48, and 41%, respectively. Cutaneous dyspigmentation was also reduced to only localized or spotty areas. The treated

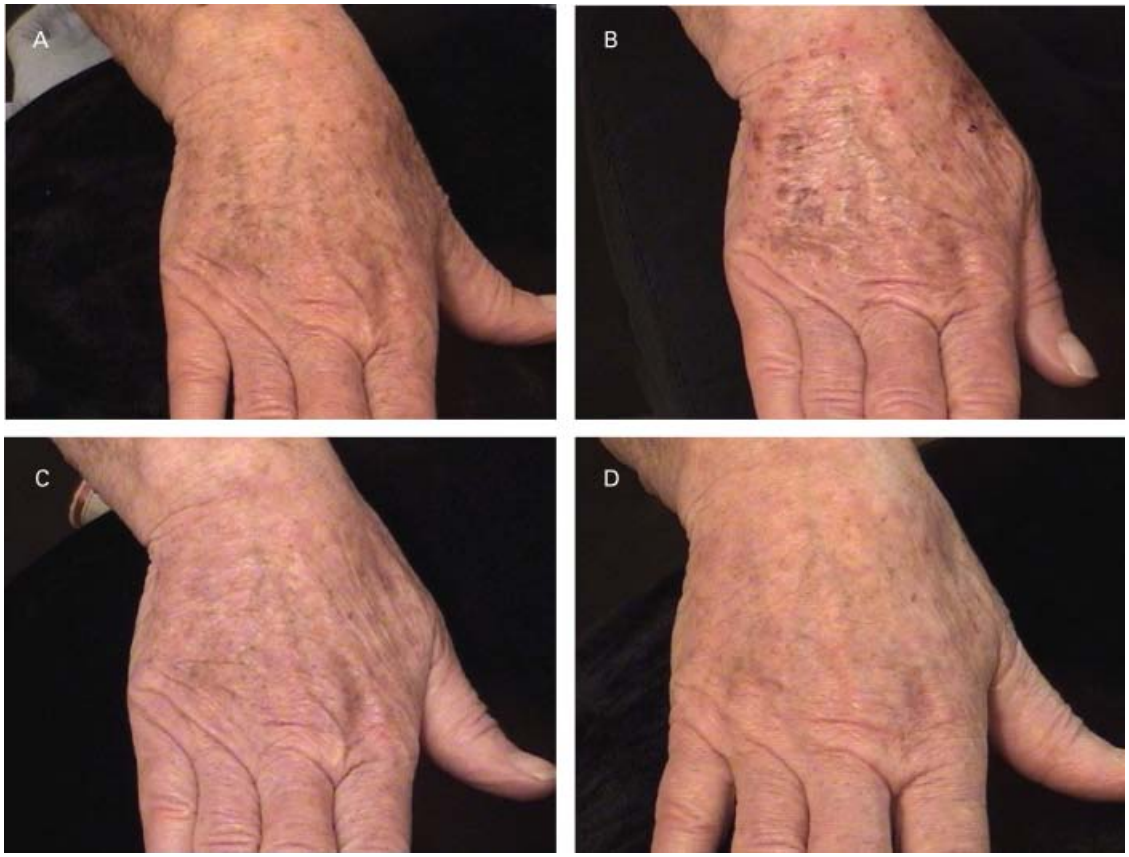

Figure 2. Photodamaged skin on the dorsal hands before (A) and 4 days (B), 14 days (C), and 90 days (D) after PSR treatment. (A and B) Wrinkle grade, 6; pigment grade, 2. (C) Wrinkle grade, 4; pigment grade, 1. (D) Wrinkle grade, 3; pigment grade, 1.

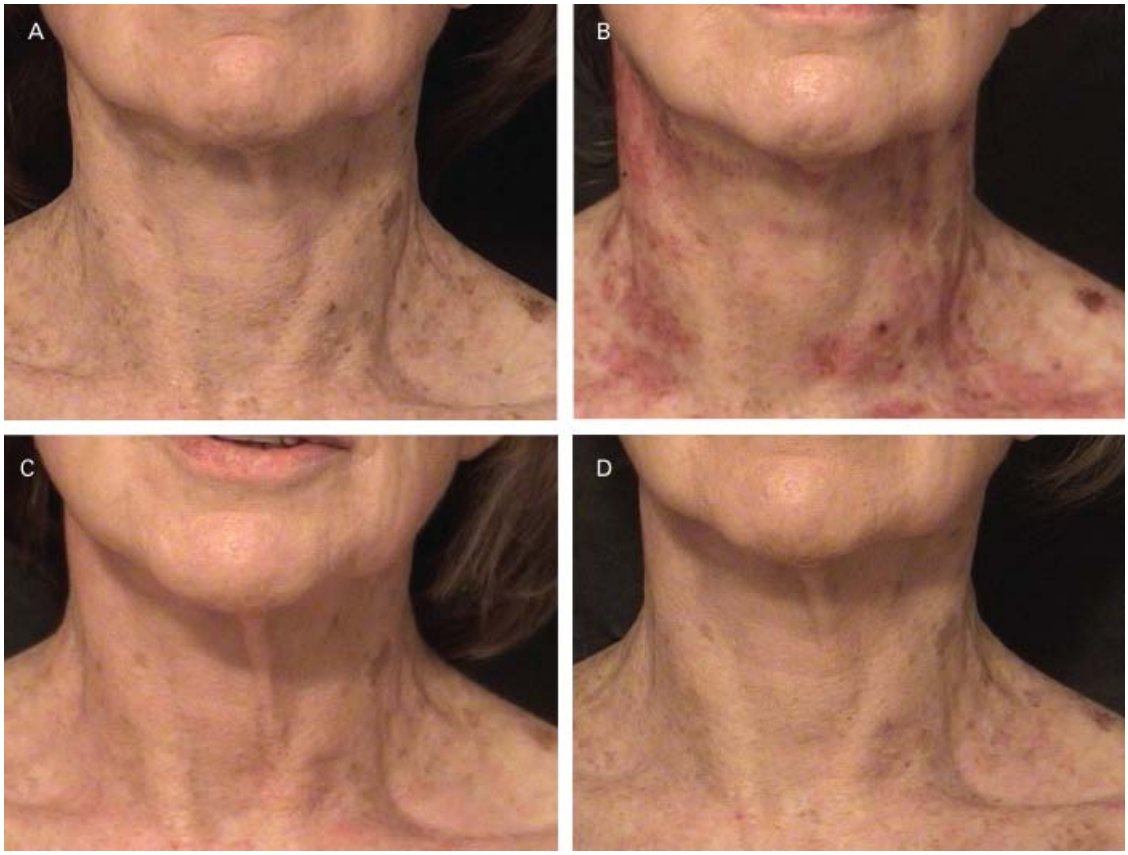

Figure 3. Photodamaged neck skin before (A) and 4 days (B), 14 days (C), and 90 days (D) after PSR treatment. (A and B) Wrinkle grade, 5; pigment grade, 2. (C and D) Wrinkle grade, 3; pigment grade, 1.

skin exhibited significant improvement in skin smoothness. Subjective patient evaluations supported the clinical measurements outlined, with prolonged positive effects of treatment evident in all areas. It is interesting that a slight (but insignificant) reduction in clinical improvement was noted in the dorsal hand regions 90 days after treatment, perhaps related to subsequent exposure of these sites to UV light. The diminution of clinical improvement observed over time suggests that additional treatments would prove useful for further enhancement and maintenance of clinical effect. In addition, although the use of higher-energy settings yielded greater clinical benefit, the associated prolonged tissue healing

TABLE 1. Clinical Results: Wrinkle Severity*

Location	*Before treatment*	*Posttreatment Day* 30	90
Neck	4.2	2.6 ($p<.001$)	2.7 ($p<.001$)
Chest	3.6	2.1 ($p<.001$)	2.1 ($p<.001$)
Hands	4.1	2.5 ($p<.001$)	2.4 ($p<.001$)

*Wrinkle severity: Grade 1 = no wrinkles; Grade 9 = fully wrinkled.

TABLE 2. Clinical Results: Hyperpigmentation*

Location	*Before treatment*	*Posttreatment Day* 30	90
Neck	2	0.67 ($p<.001$)	0.6 ($p<.001$)
Chest	2.3	0.8 ($p<.001$)	0.75 ($p<.001$)
Hands	1.8	0.07 ($p<.001$)	0.4 ($p<.001$)

*Hyperpigmentation grade: 0 = absent; 1 = localized/spotty; 2 = large patches; 3 = moderately widespread; 4 = very widespread.

TABLE 3. Clinical Results: Smoothness*

	Posttreatment Day	
Location	*30*	*90*
Neck	7.9	8.75
Chest	7.6	8.75
Hands	8.1	8.45

*Smoothness rating: 0 = very rough; 10 = very smooth.

also suggests that the use of lower energy settings over multiple treatment sessions would be more clinically relevant. Prior studies on facial skin with low-fluence, multiple PSR treatment sessions have shown significant clinical improvement with fewer side effects and shorter recovery times.[14,15]

Conclusions

PSR can be safely applied to nonfacial areas to achieve rejuvenative cutaneous effects. Ablative lasers offer maximum clinical benefit with increased prevalence of dermal wounds and morbidity while nonablative lasers offer minimal clinical benefit and minimal morbidity. This novel PSR system offers a compromise between the two treatments, providing patients with ablativelike clinical results as well as the minimal morbidity associated with nonablative techniques. Further studies are needed to determine the effect of multiple treatment sessions, optimal treatment parameters and intervals for each site, and longevity of clinical results.

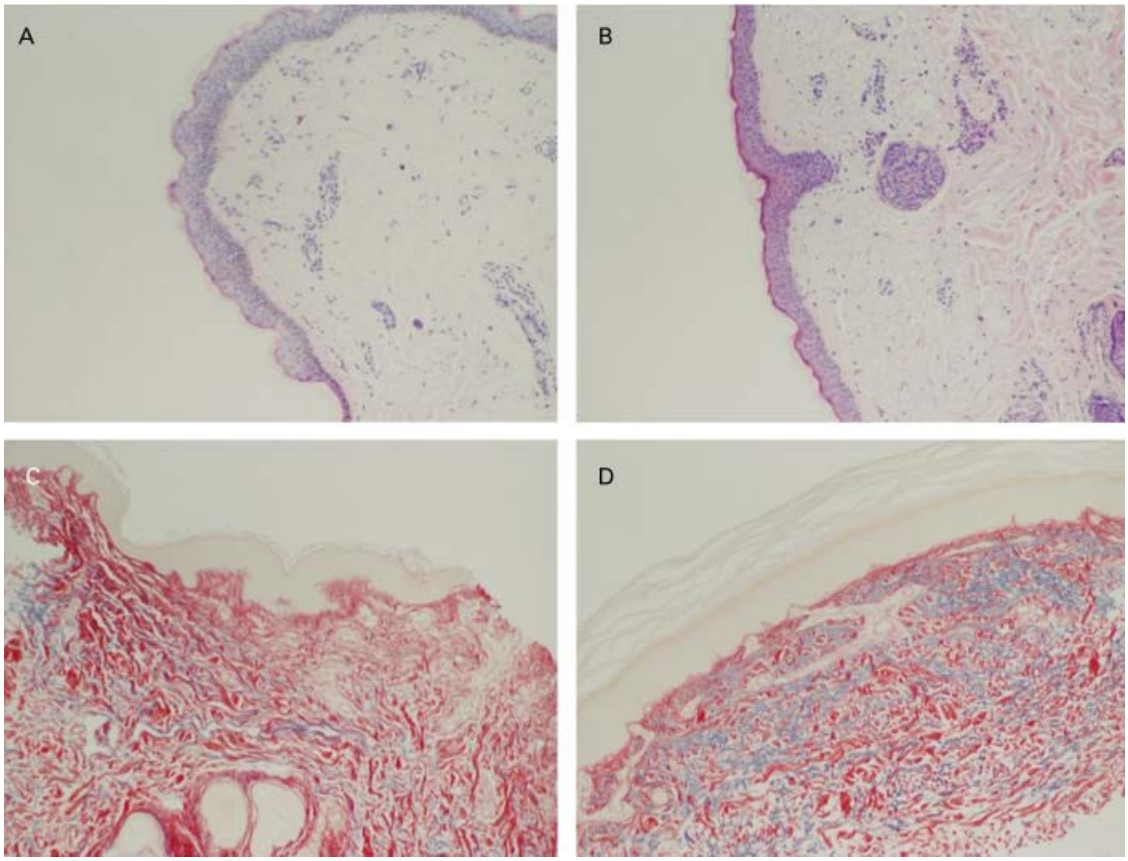

Figure 4. Histology (H&E; original magnifications, × 100) of chest skin pretreatment demonstrates flattened rete ridges, dermal–epidermal junction pigmentation, and dermal elastosis (A). After PSR treatment, epidermal normalization, minimal elastosis, and increased reticular collagen fibers are evident in the upper dermis (B). Elastin staining of specimens (original magnification, × 100) shows evidence of increased number and size of elastic fibers 90 days after PSR treatment (D), compared to before treatment (C).

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