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Treatment of Traumatic Scars Using Plasma Skin Regeneration (PSR) System

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Objectives: Several modalities have been advocated to treat traumatic scars, including surgical techniques and laser resurfacing. Recently, a plasma skin regeneration (PSR) system has been investigated. There are no reports on plasma treatment of traumatic scars. The objective of our study is to evaluate the effectiveness and complications of plasma treatment of traumatic scars in Asian patients.
Materials and Methods: Twenty Asian patients with traumatic scars were enrolled in the study. Three treatments were performed at monthly intervals with PSR, using energy settings of 2 to 3J. Patients were seen 1 week after each individual treatment and 3 months after the last treatment. Improvement was determined by patient questionnaires and physician evaluation of digital photographs taken prior to treatment and at 3 months post-treatment. The patients were also evaluated for any side effects from the treatment.
Results: Nine of 20 patients showed more than 50% improvement. The average pain score on a 10 point scale was 5.8 ± 1.3 SD and all patients tolerated the treatments. The average re-epithelization time was 7.3 ± 2.8 SD days. Temporary and local hyperpigmentation was observed in four patients and this hyperpigmentation disappeared within 3 months. Hypopigmentation and worsening of scarring were not observed.
Conclusions: Plasma treatment is clinically effective and is associated with minimal complications when used to treat traumatic scars in Asian patients. However, deep traumatic scars are resistant to plasma treatment. Lasers Surg. Med. 41:128–130, 2009. © 2009 Wiley-Liss, Inc.

Key words: plasma skin regeneration; trauma; scars; resurfacing; Asians

INTRODUCTION

Laser treatment of scars was first reported in 1980s using continuous wave carbon dioxide (CO_2), argon and neodymium/yttrium-aluminum-garnet (YAG) lasers. Results were operator-dependent and scar recurrence or worsening of scarring was observed [1]. In the 1990s, high-energy pulsed CO_2 and erbium/YAG (Er/YAG) lasers had become available and did improve scars and caused fewer significant side effects [2]. However, the epidermis is significantly damaged with use of these lasers and this can result in potential adverse effects, including prolonged erythema and pigmentary disturbances, especially in Asians [3].

The plasma skin regeneration system (PSR; Portrait, Rhytec, Inc., Waltham, MA) is a novel device that utilizes radiofrequency to convert nitrogen gas into a high energy state of matter called plasma. PSR has been shown to remove benign skin lesions with similar efficacy and a lower complication rate when compared to the CO_2 laser [4]. We hypothesized that the PSR system would be effective in improving traumatic scars, with minimal down-time and few side effects.

MATERIALS AND METHODS

Twenty Asian patients with traumatic scars and Fitzpatrick skin types III or IV were enrolled in the study (Table 1). Patients with a history of keloid formation, prior dermabrasion or laser treatment, or isotretinoin use within the last 6 months were not enrolled in the study. Patients were divided into three groups, group 1: re-epithelization was completed within 2 weeks after the traumatic injury, group 2: re-epithelization was completed between 2 to 4 weeks after the traumatic injury, group 3: epithelization was not complete until over 4 weeks after the traumatic injury. Three treatments were performed at monthly intervals with PSR, using energy settings of 2 to 3J, single pass 20% overlap. Before each plasma treatment, ten-percent lidocaine cream was applied to the treatment site for 1 hour. Immediately after treatment, patients were asked to rate their pain level. Pain was assessed using a visual analog scale (VAS, 0–10). Patients were seen 1 week after each treatment and also and 3 months after the last treatment. Blinded assessments of the treatment response were made by two expert plastic surgeons who examined digital photographs taken pretreatment (baseline) and 3 months after the last treatment. Apparent improvement of the lesion was given a score based on the following: 0 = 0%; 1 = 1% to 25%; 2 = 26% to 50%; 3 = 51% to 75%; and 4 = 76% to 100%. Adverse effects, including pigmentary

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TABLE 1. Demographic Data

No. of patients	20
Sex	8 male/12 female
Age	28.4 ± 13.3
Area	Face (8/20), extremity (12/20)
Etiology	Burn (10/20), abrasion (10/20)

TABLE 3. Complications

VAS pain score (0–10)	5.8 ± 1.3
Epithelization time (days) after plasma treatment	7.3 ± 3.1
Infections	0/20
Hyperpigmentation	4/20
Hypopigmentation	0/20
Worsening of scarring	0/20

changes and worsening of the traumatic scarring, were recorded by the same investigator who performed the treatments.

RESULTS

All patients completed the study. As judged by 2 expert plastic surgeons, 5 in 5 and 4 in 9 of the patients had more than 50% improvement in group 1 (3 burn patients and 2 abrasion patients) and group 2 (4 burn patients and 5 abrasion patients), respectively. However, only 1 in 6 patients had more than 50% improvement in group 3 (3 burn patients and 3 abrasion patients, Table 2). The average age of the scars is 6.2 years. There is no statistic difference between the burn patients and abrasion patients ($P = 0.887$). The average pain score on a 10 point scale was 5.8 and all patients tolerated the procedures. The average re-epithelization time was 7.3 days. Temporary hyperpigmentation was observed in four patients and disappeared within 3 months. No new scarring occurred as a result of the procedures (Table 3).

DISCUSSION

While dramatic improvement is seen when using ablative CO_2 laser resurfacing to treat facial traumatic scars, it is operator dependent. Moreover, the epidermis is significantly damaged during this process and this can be associated with serious adverse effects, particularly when using this modality to treat scarring off the face. These side effects include transient or prolonged erythema, temporary and permanent hypopigmentation, hyperpigmentation, infection and scarring, especially in Asians [1,3]. The plasma skin regeneration system is a novel device that utilizes radiofrequency to convert nitrogen gas into a high energy state of matter called plasma [5–7]. The plasma is emitted at 5–15 milliseconds pulses into the skin and can be delivered at 1–4 J of energy. Because the plasma skin regeneration device is not a laser, its mechanism of action is not dependent on chromophores. There is no direct means for radio frequency transfer into the treatment area. Rapid heating of the skin occurs as the excited gas gives up energy to the skin. The epidermis becomes nonviable and there is controlled thermal modification to the underlying dermis with minimal thermal injury to surrounding tissues. The zone of thermal injury is less than the CO_2 laser [4].

Plasma treatment is used for skin rejuvenation. Bogle et al. reported that with plasma skin rejuvenation, using a multiple treatment, low-energy (1.2–1.8 J) technique, physicians can successfully improve photodamaged facial skin with minimal downtime [5]. In Bogle's study, re-epithelialization was completed in 4 days and only temporary hyperpigmentation was observed. More recently, Gonzalez et al. [8] reported a single high-energy (3.5–4 J) plasma treatment can significantly improve acne scarring. Their study demonstrates that, while the magnitude of improvement with plasma treatment is not as dramatic as that seen with multi-pass CO_2 laser treatment, a high energy, double pass, PSR treatment requires minimal operator training to achieve predictable and safe improvement in acne scars. In contrast to aggressive ablative techniques, plasma regeneration maintains the integrity of the epidermis, which leads to less social downtime and less risk of significant side effects (Fig. 1).

Traumatic scars vary in depth, width and color. In our study, plasma treatment was effective in improving traumatic scars in Group 1 and 2, but not effective in Group 3. As seen in Figure 2, the result at the center of the scar is not good as result at the periphery of the scar. According to an animal model study, the zone of thermal damage of a 3 J single pass of plasma did not exceed 11 micrometers. In contrast a high fluence CO_2 laser treatment yields 33.4 μm of thermal damage. We believe that the scar thickness in Group 3 patients was too deep for the PSR device to be effective because good remodeling could not be achieved. Theoretically, wide and deep scars, such as abdominal surgery scars, are not good candidates for plasma treatment.

Hypertrophic scars are characterized by excessive deposition of collagen in the dermis and subcutaneous tissues secondary to traumatic or surgical injuries. Contrary to the asymptomatic fine-line scar that results from normal wound repair, the exuberant scarring of hypertrophic scars results typically in distressing disfigurement,

TABLE 2. Degree of Improvement (n = 10)

Scar (epithelization time after injury)	Worse	Poor, 0–25%	Mild, 26–50%	Moderate, 51–75%	Significant, 76–100%
Mild (within 2 weeks)	0/5	0/5	0/5	0/5	5/5
Moderate (2–4 weeks)	0/9	1/9	4/9	3/9	1/9
Severe (over 4 weeks)	0/6	5/6	1/6	0/6	0/6

Fig. 1. Thirty six-year-old female, scars on left forearm (abrasion wound, age of scar was a year and 2 months) before (left) and after three treatments (right). Significant improvement was observed.

Fig. 2. Twenty three-year-old male scars on face (abrasion wound, age of scar was 7 months) before (left) and after three treatments (right). Mild improvement was observed. The result at the center of the scar is not good as result at the periphery of the scar.

distortion, contractures, pruritis, and pain. Various therapies have been advocated in the past, including surgical excision, dermabrasion, skin grafting, carbon dioxide laser ablation, pressure therapy, cryosurgery, silicone gel or sheet application, and intralesional injection of various agents. Recently, the pulsed dye laser (PDL) has been used effectively to treat hypertrophic scars. Because, most hypertrophic scars are erythematous, it has been thought that the improvement of scarring is related to the selective destruction of blood vessels in the scars. However, theoretically and clinically, the PDL is not so effective in the treatment of mature and white scars.

Hyperpigmented scars improved in color after plasma treatment and the risk of hyper and hypopigmentation was minimal, even in dark skin patients. In our study, the average re-epithelization time was 7.3 days. In contrast to the CO_2 laser, plasma treatment maintains the integrity of the epidermis, leading to less downtime. Plasma treatment appears to provide a safe and effective treatment of traumatic scars.

CONCLUSION

In this study, the plasma treatment appeared to be a safe and effective for treating traumatic scars. However, deep traumatic scars are still resistant to plasma treatment. Future studies are needed to explore the potential use of higher fluence treatments, double pass treatments and a sequence of treatments.

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