Journal of Cosmetic and Laser Therapy. 2006; 8: 35–38

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CASE REPORT

Fractional photothermolysis for the treatment of surgical scars: A case report

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Abstract
Background. Surgical scars are a challenging condition to treat. Fractional photothermolysis provides a promising new modality for treatment.
Case report. A 55-year-old white female patient with a surgical scar on the chin was treated with fractional photothermolysis (1550 nm Fraxel™ SR laser). A single treatment session was performed at pulse energy of 8 mJ (MTZ) and a final density of 2000 MTZ/cm^2. The treatment response was assessed by comparing pre- and 2-week post-treatment clinical photography.
Results. A greater than 75% clinical improvement of scarring was achieved at 2 weeks after a single treatment based on independent physician assessment. No significant adverse effects were noted. The improvement was persistent at 1-month follow-up.
Conclusion. Fractional photothermolysis offers a new, effective, and safe modality for the treatment of surgical scars.

Key words: *Fractional photothermolysis, Fraxel, scar, laser, surgical*

Background

Hypertrophic scars are a common complication among patients suffering from surgical procedures, traumatic wounds, or burn injuries. They are elevated, firm and erythematous because of the increase in microvasculature (1). Hypertrophic scars are primarily of cosmetic concern, especially on the face; however, some lesions can cause contractures, which may result in loss of function if overlying a joint. They can be both painful and pruritic, and approximately 1.5–4.5% of the general population is affected (2). The mechanism of hypertrophic scar formation is still not completely understood. Abundant collagen accumulation and fibroplasia may result from either excessive synthesis of collagen, fibrin, and proteoglycans or deficient matrix degradation and remodeling (3).

The treatment of hypertrophic scars is challenging because of the high recurrence rate and the incidence of side effects associated with treatment (4). The pulsed dye laser at the 585–595 nm wavelength, which relies on the principle of selective photothermolysis (5), is the current standard for treatment of hypertrophic scars (2,6–22). However, clinical studies have shown that complete clearing of erythema and/or thickness of scars is not commonly achieved, and multiple treatment sessions are usually required to obtain optimum clearing (2,8,14,15,17–22). Moreover, in some cases, hypertrophic scars are poorly responsive to conventional pulsed dye laser irradiation (23).

In contrast to selective photothermolysis, which aims to produce bulk thermal injury in particular targets within skin, fractional photothermolysis creates hundreds to thousands of microthermal zones (MTZs) and spares the tissue surrounding each MTZ (24,25). We report the case of a white female patient with scarring of the chin secondary to surgical excision of a basal cell carcinoma who was treated with a single treatment of fractional photothermolysis resulting in a greater than 75% clinical improvement based on independent physician assessment of clinical photography.

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(Received 15 September 2005; accepted 30 November 2005)

ISSN 1476-4172 print/ISSN 1476-4180 online © 2006 Taylor & Francis
DOI: 10.1080/14764170600607251

Case report

A 55-year-old white female patient with Fitzpatrick type II skin (26) presented with scarring to the left side of the chin (Figure 1), which had resulted from Mohs' excision of a basal cell carcinoma 4 weeks prior to presentation. The patient denied a history of keloid formation or isotretinoin use within the last 6 months. The treatment area was thoroughly cleansed prior to the procedure using a mild, gently abrasive skin cleanser. OptiGuide Blue, a FDA certified water-soluble tint, was applied to the treatment area to highlight the contours of the skin. This allowed the laser's intelligent optical tracking system to detect contact with the skin and to adjust the treatment pattern with respect to handpiece velocity. For 1 hour prior to treatment, 30% topical lidocaine ointment was applied. A single treatment with the 1550 nm wavelength Fraxel (R) SR laser (Reliant Technologies Inc., Mountain View, CA, USA) at pulse energy of 8 mJ and a final density of 2000 MTZ/cm^2 was performed.

Postoperative erythema was noted, which resolved within 24 hours. Follow-up results at 2 weeks revealed a greater than 75% clinical improvement in the degree of erythema, induration, and overall texture based on independent physician clinical assessment using a quartile grading scale (0–25%: no improvement; 25–50%: mild improvement; 50–75%: moderate improvement; > 75%: dramatic improvement). The patient's degree of satisfaction paralleled the physician's assessment of improvement (Figure 2). A 1-month follow-up visit revealed persistence in clinical improvement.

Discussion

The flashlamp-pumped pulsed dye laser utilizes the principle of selective photothermolysis and has extensively been used for the treatment of hypertrophic scars (2,6–22). This treatment modality is based on the hypothesis that by selectively destroying the vascular component of hypertrophic scars clinical improvement may be seen (6,7,10). New vessel formation is essential to supply the nutrients that are necessary for the production of collagen and extracellular matrices (11). However, clinical experience has shown that complete clearing of erythema and/or thickness of scars may not always be achieved, and multiple treatment sessions are usually required to obtain optimal clearing (2,8,14,15, 17–22). In some cases, hypertrophic scars are poorly responsive to pulsed dye laser irradiation (23).

Figure 1. Post-surgical scar on the chin before treatment with fractional photothermolysis.

Figure 2. Two weeks following a single treatment. Both an independent physician evaluator and the patient reported a greater than 75% improvement in the degree of erythema, induration, and overall texture of the skin.

One reason for this limited therapeutic outcome is postulated to be the limited light penetration depth in blood at the 585 nm wavelength, which is approximately 52 μm (absorption coefficient $\mu_a \approx 191$ cm^{-1}) (27). Hypertrophic scars are usually several millimeters thick (28) and, as a result, deeply located blood vessels cannot be coagulated by pulsed dye laser irradiation, resulting in incomplete clearing of these lesions. Additionally, while the risk of hypertrophic scar formation is 2–14-fold higher in patients with dark skin (Fitzpatrick skin types V–VI) than those with light skin (Fitzpatrick skin types I–IV) (29), the former patient population is at a higher risk of adverse effects due to light absorption by epidermal melanin at the 585–595 nm wavelength, which can lead to post-inflammatory hyper- and hypopigmentation and texture changes to the skin (30–32).

The 1550 nm wavelength of fractional photothermolysis targets tissue water but not melanin. Therefore, it can be used on patients with all skin types. As fractional photothermolysis produces microscopic zones of thermal injury surrounded by uninjured tissue, epidermal repair is fast due to a small volume of injury and short migratory paths for keratinocytes (24). Furthermore, the stratum corneum remains intact during exposure to the 1550 nm wavelength laser as relatively less water is contained in it, and this reduces the risk of infection substantially. The 1550 nm wavelength allows a light penetration of about 1000 μm into skin ($\mu_a \approx 9.6$ cm^{-1} in water and blood) (33), which makes the photothermolysis of deeply located blood vessels possible and potentially a benefit compared with the pulsed dye laser which cannot penetrate to this depth. In addition, the 'fractional', or the micro-beam-composed, laser avoids bulk heating of the skin dermis, as is the case in conventional pulsed mid-infrared lasers. For a pulse of 8 mJ and density of 2000 MTZ/cm^2, only approximately 15% of the treated area is actually heated. This reduces the risk of irreversible non-specific thermal injury to the dermis, which may worsen scarring. The sizes of the blood vessels in hypertrophic scars range from 3.3 to 14.6 μm (34), while the average size of the micro beam emitted from the fractional photothermolysis laser is about 100 μm in diameter. Therefore, the micro beam is sufficiently large to destroy individual blood vessels in hypertrophic scars. This presents a unique feature of fractional photothermolysis for the treatment of hypertrophic scars: on one hand, the thermal injury is small so that normal tissue repair is rapid; yet, on the other hand, the thermal injury is sufficiently large to irreversibly destroy individual blood vessels. This feature was shown by the histological results of a recent clinical study, which demonstrated the direct dermal vascular injury after the treatment of fractional photothermolysis (35). By adjusting the optical focal depth and/or the energy of fractional photothermolysis, high local radiant exposure can be achieved (24). Hence, different tissue compartments (e.g. blood vessels, dermal melanin, and sebaceous glands) at various depths of the skin can be arbitrarily selected as the targets for photothermolysis. With an appropriate MTZ density, an effective macroscopic treatment can be achieved.

Recent clinical studies on the fractional photothermolysis of surgical scars show that improvement in skin texture can be achieved in four to five treatment sessions (36,37). In this report, a greater than 75% clinical improvement was obtained after only a single treatment. The present case report suggests that fractional photothermolysis has the potential to be effective and safe in treating surgical scars. Additional studies with a larger number of patients of all skin types and with a longer-term follow-up are needed to further assess the efficacy and safety of fractional photothermolysis for the treatment of surgical scars, and to define the optimal treatment parameters.

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