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Ablative Fractional Resurfacing for Chronic Wounds from Traumatic Scarring: A Case Report and Literature Review

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ABSTRACT

Ablative fractional resurfacing (AFR) can be utilized to improve scar appearance, texture, pain and associated contractures. Non-healing ulcers can also develop in areas of scarring and, in some cases, AFR can be utilized to heal these chronic wounds. We present a case of scarring with non-healing ulceration refractory to wound care, debridement and hydrotherapy successfully healed in four sessions with AFR using a 2940 nm Er:YAG laser. We review the literature on AFR for wound healing including potential mechanisms. AFR can be considered for non-healing ulcers in areas of scarring, once malignancy and infection are ruled out, and has the potential to provide relief for these suffering patients.

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INTRODUCTION

The efficacy of lasers for scar treatment is well documented and multiple lasers are known to improve scars. Ablative fractional resurfacing (AFR) can be especially beneficial to improve scar appearance, texture, pain and associated contractures.[1] AFR is performed with carbon dioxide (CO_2) and erbium yttrium aluminum garnet (Er:YAG) lasers with water as the target chromophore.

Fractional photothermolysis works by creating columns or microthermal treatment zones (MTZs) of controlled thermal injury with a grid-like pattern at an operator-determined depth and density.[2] The clinician can target the approximate depth of the scar and make depth and density adjustments based on body location as well as scar characteristics. The healthy skin between the MTZs facilitates a rapid wound healing response contributing collagen reconstruction and scar remodeling.[3] The ablated pinholes from AFR also relax skin contractures, promoting improvement, some immediate, in areas of tension.[4,5] The open MTZs also can act as channels for topical drug delivery, which can be used to enhance treatment and achieve less painful more uniform distribution of drugs.[6]

AFR has been established as the first line method for the treatment for traumatic scars in many centers.[7,8] Multiple studies have consistently documented significant subjective and objective improvements in scar appearance, color, height, texture, pliability, restriction, pain and itch, as well as an overall improvement in quality of life.[8] Most experts agree that AFR is the most effective overall laser platform for traumatic scars.[8]

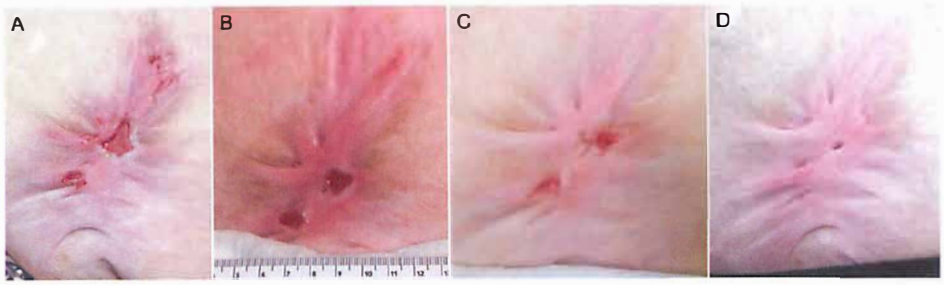
Non-healing ulcers can develop in areas of scarring. Previous reports have demonstrated success treating select chronic ulcers in the presence of scar contractures with AFR, citing decreased tension from improved scar pliability and texture, along with potential wound debridement, biofilm disruption, and molecular changes in the skin.[1,9-13] We present a case of traumatic scarring with non-healing ulceration treated with AFR to facilitate wound healing and then review the literature on this indication for AFR.

CASE REPORT

A 69-year-old obese and hypertensive female presented with a two-year history of multiple chronic, non-healing ulcers on the central abdomen with surrounding scarring refractory to standard wound care. Four years prior, a dermatitis of unspecified etiology developed, and ulceration occurred. The cause of the ulceration was unclear but pruritus and aggressive scratching were thought to have contributed per chart review. Months later, she underwent an Oasis® grafting procedure. The graft became pruritic and the wounds returned, grew in size, and became increasingly painful. Biopsies were performed to rule out malignancy, fungal infection, and vasculitis. The wounds were repeatedly infected and did not respond to wound care, debridement, or hydrotherapy.

After multiple cycles of wound-improvement and recurrence, the wound-care specialist referred the patient for AFR in an effort to assist with wound healing. On physical exam, multiple open erosions on the central abdomen ranging from 1 to 3 cm in size were present with surrounding contracted scar tissue measuring about 8 cm x 5 cm. After evaluation, we proceeded with AFR using a 2940 nm Er:YAG laser (Sciton, Profractional, Palo Alto, CA). Prior to each laser application, the treatment area was topically anesthetized for 1 hour, cleaned

FIGURE 1. The appearance of the patient's scar and non-healing ulcer (A) upon presentation, (B) three weeks after the first laser treatment, (C) immediately prior to the third treatment, and (D) immediately prior to the fourth and final AFR treatment. The patient did not return for follow-up after the fourth treatment.



with chlorhexidine followed by sterile water, then carefully dried. Appropriate eyewear and masks were worn, and a smoke evacuator was used. The patient was treated four times at 6 to 8-week intervals using a fractionated 2940 nm Er:YAG Profractional laser (Sciton, Palo Alto, CA) with settings of 5.5% density and fluence ranging from 162.5-187.5 J/cm^2. The ulcer and surrounding area of scar were treated. The open wounds healed completely over the course of treatment (Figure 1). No adverse effects or complications were observed.

DISCUSSION

Lasers are known to improve scars and are commonly used by dermatologic, plastic and burn surgeons to decrease scar associated morbidity.[14] AFR was first introduced in 2007 and has subsequently become widely accepted as a first-line treatment for traumatic scarring.[7,8] We report a case where AFR was used to mitigate scarring and heal a chronic ulcer refractory to other treatments. Complete healing of the chronic wounds was achieved.

Prior works (Table 1) have evaluated AFR for the healing of chronic wounds.[1,9,12] Cases presented by Uebelhoer et al and Shumaker et al included severe scarring, contractures, and chronic nonhealing wounds from burns[1] and an explosive device blast[9] refractory to split-thickness skin grafting, physical therapy, and proper wound care. The scars on both patients were treated with CO_2 AFR using fluences ranging from 17.5 to 50 mJ and densities between 5 and 15%. The chronic wounds were treated with lower fluences and 3 to 5 weeks after a single AFR treatment, the ulcers in these patients were completely re-epithelialized. Another 3-patient case series by the same group included nonhealing wounds and severe scarring after explosive device injuries and reported complete reepithelization after AFR.

Additional case reports have been published on nonhealing wounds in elderly patients, resulting from trauma and Mohs micrographic surgery, that responded to AFR.[11] Laser parameters included 30 mJ of energy at 5% density applied to the base of the wounds and 50 mJ to the surrounding skin for only one treatment, and complete healing was observed after 3 to 6 weeks, including in one diabetic patient.[11] In another pilot study, ultrapulsed CO_2 laser at 4J was administered weekly to nine patients with diabetic ulcers with exposed bone.[15] After a maximum of six treatments, four patients completely healed, one developed granulation tissue, three did not heal, and one underwent minor amputation.[15] In the same study with the same treatment parameters, AFR was combined with platelet-rich plasma for the treatment of diabetic foot ulcers with exposed bone in five elderly patients, two of which healed in three months, two more developed granulation tissue, and the final patient saw no improvement and underwent amputation.[15]

Reported cases of AFR application in chronic wounds of pediatric patients have also demonstrated benefit.[12] Krakowski et al used AFR on an 8-year-old healthy female with restrictive scarring and a nonhealing wound of eight months duration on her forearm from a chemical burn. Aggressive cryotherapy caused nonhealing wounds in a 17-year-old healthy male, which failed to heal after proper wound care, possibly due to recurrent trauma from football practice. The chronic wounds in both cases were treated twice using ablative fractional CO_2 at a fluence of 50 mJ and density of 5%, resulting in complete re-epitheliazation and improvement in scar texture and pliability.[12]

The method of wound closure prompted by AFR warrants exploration. One theory is that AFR allows local relaxation of tissue and perhaps generation of additional collagen, relaxing tension in the scar area and allowing chronic wounds to close. By improving the pliability of the surrounding skin, oxygen circulation to the wound may also be increased, fostering more rapid healing.[11] Other theories suggest AFR of chronic wounds exerts mechanical effects, stimulates collagen remodeling and triggers angiogenesis to activate a more effective wound healing process.[16]

AFR has shown efficacy in the treatment of acute induced wounds in diabetic mice, more effectively reducing the size of the original wound when compared to natural healing.[17] In this study, treatment groups exhibited significantly increased vascular endothelial growth factor (VEGF) and basic fibroblast growth factor (bFGF) mRNA expression with reductions in the expression of transformation growth factor-ß (TGF-ß) mRNA.[17]

TABLE 1.

Summary of Prior Cases

Publication	Age	Sex	Injury	Location	Laser	Settings	No. of Tx	Outcomes
Uebelhoer et al 2012[1]	52	M	Burn scar with contracture and non-healing ulcer	R elbow	PDL	4 J/cm² fluence, 1.5 ms pulse duration, 10 mm spot size	1	2 weeks post: additional 12 degrees extension.
					AF CO_2	40 mJ fluence (20 mJ at wound base), 5% density		5 weeks post: increased extension and full re-epitheliazation of the ulcer.
SHUMAKER et al 2012[9]	22	M	Explosive device blast with poor skin mobility with skin fragility and chronic ulcers	L leg amputation stump	AF CO_2	17.5-50 mJ fluence, 5% to 15% density with higher fluences necessitating decreased density	2	3 weeks post initial treatment: significant interval improvement in wound healing skin pliability, and durability allowing prosthetic use. 3 months post final treatment: Progressive improvement and undergoing rehabilitation and walking.
	26	M	Explosive device blast with poor skin mobility with skin fragility and chronic ulcers	R leg amputation stump	AF CO_2	50 mJ, 5% density, 250 µs pulse duration, 120 µm spot size	2	8 months post final treatment: improvements in texture, pigmentation, and skin pliability. Complete resolution of ulcers.
Shumaker et al 2012[10]	28	M	Explosive device blast with hyper-trophic graft site and persistent erosion	R amputation stump	AF CO_2	30 mJ, 5% density, 250 µs pulse duration, 120 µm spot size	2	Complete re-epithelialization of erosion 6 days post treatment. Improved skin texture and pliability.
	39	M	Explosive device blast with persistent ulcer and scar contracture	R elbow	AF CO_2	50 and 30 mJ, 5% density, 250 µs pulse duration, 120 µm spot size	3	Sustained healing of the ulcer during follow-up. Improved skin pliability and range of motion.
Phillips et al 2015[11]	70	F	Degloving injury with non-healing wound	Dorsum of foot	AF CO_2	50 mJ fluence (30 mJ at wound base), 5% density	1	Wound was completely healed 6 weeks after treatment.
	70	M	Non-healing Mohs surgical wound	R shin	AF CO_2	50 mJ fluence (30 mJ at wound base), 5% density	1	Wound was completely healed 3 weeks after treatment.
Krakowski et al 2016[12]	8	F	Scalding chemical burn injury with non-healing wound from repetitive friction	L forearm with contractures	AF CO_2	50 mJ fluence, 5% density	2	2 months post initial treatment: near-complete healing. 2 months post final treatment: complete re-epithelialization with improved skin pliability and texture.
	17	M	Aggressive cryotherapy of verruca vulgaris; non-healing wounds resulting from repeated football practice	L shin	AF CO_2	50 mJ fluence, 5% density	2	1 month post initial treatment: near complete granulation. 1 month post final treatment: complete healing. 4 months post final treatment: complete healing with residual post-inflammatory dyspigmentation.
This report	69	F	Rash subject constant scratching	Abdomen	AF Er:YAG	162.5-187.5 J/cm², 5% density	4	The open wound gradually healed over the course of treatment. No adverse effects were observed.

AF: Ablative Fractional; PDL: Pulsed dye laser; Er:YAG: Erbium yttrium aluminum garnet laser; CO_2: Carbon dioxide laser

Discussions of histological and biochemical changes involved in AFR have focused on the upregulation of TGF-ß, heat shock proteins (HSP), and matrix metalloproteinases (MMP).[18] TGF-ß signaling is often documented as suppressed in chronic wounds but its role in wound healing is still unclear.[18-21] HSPs have been established as regulators of the wound healing response by promoting or suppressing TGF-ß expression and fibrosis.[18,22-30] Additionally, different MMPs are stimulated throughout different phases of the wound healing process after AFR, regulating collagen synthesis and degradation.[18,31]

It is important to note that not every non healing ulcer in an area of scarring would be a good candidate for laser treatment. Malignancy and infection need to be ruled out with appropriate techniques, including biopsy and culture. The potential contribution of vascular compromise must also be considered. However, once other contributing factors are explored, then AFR may be considered.

AFR has revolutionized scar treatment and, as demonstrated by this case and review, can benefit select patients with chronic wounds in the setting of scarring. AFR should be considered for non-healing ulcers in areas of scarring, as it can provide the potential for relief for these suffering patients.

CONCLUSION

AFR can be considered for non-healing ulcers in areas of scarring, once malignancy and infection are ruled out. There are multiple theories regarding the mechanism of action, but further investigation is warranted.

DISCLOSURES

The second author is a consultant for Sciton Inc., who provided the device used in this case report.

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