Ablative Fractional Carbon Dioxide Laser in the Treatment of Chronic, Posttraumatic, Lower-Extremity Ulcers in Elderly Patients

Tania J. Phillips, MD, FRCPC; Laurel M. Morton, MD; Nathan S. Uebelhoer, DO; Jeffrey S. Dover, MD, FRCPC

Treating posttraumatic lower-extremity wounds can be challenging, especially in elderly patients. Recently, the use of fractional carbon dioxide laser has been shown to improve wound healing in scar-related wounds. We used this treatment modality in posttraumatic wounds that were slow to heal in 3 elderly patients.

Importance
Treating posttraumatic lower extremity wounds can be challenging, especially in elderly patients. Recently, the use of fractional carbon dioxide laser has been shown to improve wound healing in scar-related wounds. We used this treatment modality in posttraumatic wounds that were slow to heal in 3 elderly patients.

Observations
Each wound underwent one fractional carbon dioxide laser treatment. The wound base was treated at 30 mJ and 5% density. The entire wound edge and 1 to 2 cm into the normal surrounding skin were treated at 50 mJ and 5% density. One pass was completed at 150 Hz per treatment. Treatments were well tolerated with only mild discomfort. Each wound healed by 60% or greater within 3 weeks. No adverse events were reported aside from mild and transient erythema at site of treatment.

Conclusions and Relevance
Fractional carbon dioxide laser treatment appeared to accelerate healing in each of these posttraumatic wounds. It may be a helpful adjunct in nonhealing posttraumatic wounds.

Case Report/Case Series
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Treating posttraumatic lower-extremity wounds can be challenging, especially in elderly patients. Recently, the use of the fractional carbon dioxide laser has been shown to improve wound healing in scar-related wounds. We used this treatment modality in posttraumatic wounds that were slow to heal in 3 elderly patients. Because of the observational nature of this report, it was not submitted for institutional review board approval. Both oral and written patient consent was obtained for the laser treatment.

Report of Cases

Case 1
A woman in her 70s had a traumatic injury to the dorsum of the left foot following a degloving injury after a motor vehicle crash. The wound was sutured, but dehisced, and the patient was left with an open wound on the dorsum of the foot that had been present for 3 months when we first examined her. Despite frequent leg elevation, multilayer compression bandages, and nonadherent dressings applied to the wounds daily, there had been no significant decrease in wound size.

The patient reported mild ankle swelling and numbness in the foot following the accident. She had quit smoking 30 years previously and had well-controlled hypertension. On examination, there was a 3.0 × 1.7-cm (5.78 cm²) ulcer on the left dorsal foot (Figure 1A). She had mild pitting edema, bounding pulses, a warm foot, and mild neuropathy affecting the left sole. She was treated with a hydrocolloid dressing and a multilayer compression wrap (elastic bandage with overlying self-adherent wrap) for a further 2 weeks. Because of the slow healing process with compression and moisture-retentive dressings, she was treated with the Deep FX fractional carbon dioxide laser (Lumenis Ltd). Before fractional carbon dioxide laser treatment, the wound measured 3.0 × 1.7 cm. One week later, the wound appeared to be epithelializing and measured 3.0 × 1.0 cm. After another 2½ weeks, the ulcer measured 2.0 × 1.0 cm. One month after treatment, it measured 7 × 3 mm, and it was completely healed 6 weeks after treatment (Figure 1B).

Case 2
A man in his 70s had a history of multiple nonmelanoma skin cancers and well-controlled type 2 diabetes mellitus. He had undergone Mohs surgery for a basal cell carcinoma on the right shin. The surgical site was treated with a hydrocolloid dressing and a multilayer compression wrap. However, the wound was slow to heal and 6 weeks after surgery measured 1.5 × 1.5 cm (2.25 cm²). Eleven weeks after surgery, there was minimal change in the wound's size (Figure 2A). The patient received treatment with the Deep FX fractional carbon dioxide laser. Three weeks after treatment, the wound had completely healed (Figure 2B).
Case 3
A healthy woman in her 90s walked 1.6 km per day. Following Mohs surgery for a squamous cell carcinoma on the right shin, she had a nonhealing wound measuring 2.2 × 2.2 cm (4.84 cm²). Following surgery, she developed a wound infection and was treated with oral cephalixin, 500 mg, 4 times per day for 10 days. However, the wound was slow to heal despite being treated with multilayer compression wraps and hydrofiber silver dressings. The dressings were changed by the visiting nurses every 2 to 3 days. Six weeks later, the wound had only minimally decreased in size, measuring 2.2 × 1.7 cm (Figure 3A). Seven weeks after Mohs surgery, the wound was treated with the Deep FX fractional carbon dioxide laser. One week later, the wound measured 1.8 × 1.6 cm. At 3 weeks, the wound measured 1.2 × 7 mm; 3 weeks later, the wound was completely healed (Figure 3B).

Treatment Methods
Before intervention, the wounds were measured, photographs were taken, and topical lidocaine hydrochloride gel, 30%, was applied for 30 minutes and removed before treatment. Each wound underwent 1 fractional carbon dioxide laser treatment (Deep FX). The wound base was treated at 30 mJ and 5% density. The entire wound edge and 1 to 2 cm of the normal surrounding skin were treated at 50 mJ and 5% density. One pass was completed at 150 Hz per treatment. Immediately following treatment, the entire treatment site (wound base and 1-2 cm of the wound edge) was dressed with a thick layer of a commercially available healing ointment (Aquaphor [petrolatum, 41%; Eucerin], a nonstick gauze dressing, and a compression wrap. Following fractional carbon dioxide laser treatment, no adverse events were reported except for mild and transient erythema at the site of treatment. Treatments were well tolerated, with only mild discomfort.

Discussion
Before treatment, each of the patients in this series had wounds that failed to heal despite adequate wound care for 6 to 8 weeks.
Following a standard protocol treatment with a fractional carbon dioxide laser, each wound healed by 60% or more within 3 weeks. The advent of ablative fractional photothermolysis in the past decade and its application to the treatment of traumatic scars represents a breakthrough in the restoration of function and cosmetic appearance for injured patients, but the procedure is not yet widely used.

Recently, Shumaker and colleagues reported rapid healing of scar-associated ulcers in young patients following fractional carbon dioxide treatment. These patients had multiple traumatic scars following blast injuries as well as chronic focal ulcerations in the scars that had failed to heal despite good wound care. After ablative fractional resurfacing to treat the scars, there was incidental rapid healing of the wounds within 2 weeks of laser treatment. Our findings suggest that the ablative fractional carbon dioxide laser is also helpful in nonhealing posttraumatic nonscarred wounds in elderly patients.

The ablative fractional carbon dioxide laser creates a unique pattern of injury. The primary mechanism of improved healing appears to be related to the ablative laser fenestration of the relatively contracted skin at the periphery of the wound. Presumptively, by improving the pliability of the tissue at the wound edge and adjacent skin, there is, at least, an increase in oxygen and circulation to the wound, encouraging more rapid healing. In our experience, using high-energy, low-density ablative fractional carbon dioxide lasers on both the peripheral skin and wound bed yields a substantially shorter healing time than treating the peripheral skin alone. This finding suggests that other nonmechanical mechanisms may be involved and likely have a synergistic effect on healing. None of the wounds were surgically debrided before laser treatment. It is possible that the laser causes microdebridement of the wound bed, creating acute injury cytokines that may stimulate the healing process. Laser treatment may also disrupt the bacterial biofilm that is commonly present in wounds and that may impede wound healing.

Laser treatment may stimulate collagen remodeling. Ozog and colleagues demonstrated that fractional carbon dioxide ablation of hypertrophic scars leads to increased type III collagen and decreased type I collagen, favoring a ratio more typical for normal wound healing. These changes appear to occur in concert with increased expression of microRNA from the 17-92 cluster that is involved in the transforming growth factor β signaling pathway, while transforming growth factor β3 is significantly reduced. Lasers can also change the gene expression of many matrix metalloproteinases, including 1, 3, 9, 10, 11, and 13, which are all upregulated following fractional carbon dioxide laser treatment and play an important role in collagen degradation and reorganization. The fractional laser may also remove necrotic and senescent cells that inhibit wound healing. These alternate pathways are currently under investigation and may support the model of a unique injury and repair pathway.

Conclusions

It should be emphasized that our patients were in good health, without significant comorbidities, and that their wounds were posttraumatic. These results cannot be extrapolated to patients with significant venous, arterial, or chronic diabetic ulcers. Controlled studies should be conducted to further validate this modality as a second-line treatment for difficult-to-heal lower-extremity wounds.
Notable Notes

Buzzwords in Dermatology
Opening a Can of Worms

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Like moths to a flame, the phylum Arthropoda has attracted the attention of dermatologists with several classical dermatological descriptions drawn from insects.

It is well known that the malar rash in acute lupus erythematosus resembles the morphologic appearance of a butterfly, with wings spanning across the cheeks, and is hence more commonly referred to as a “butterfly rash.” Bees have inspired a number of terms, such as the characteristic transgressions palmoplantar keratoderma of Vohwinkel syndrome, which is described as having the appearance of honeycomb, as well as the colloquial “hives” of urticarial pathologic syndrome, which is described as having the appearance of a honeycomb.

The formation of delusional parasitosis draws its name from the formic acid contained in ant bites. Worms are not forgotten, with the dermatosis of atrophoderma vermiculata presenting as “worm-eaten” reticular atrophy of the skin over the cheeks, periauricular regions, and temples, and the superficial erosions in the oral mucosa of pyostomatitis vegetans have been likened to snail trails. From the Arachnida class, spider naevi are so termed such because the telangiectasia that arises from a central arteriole resemble the legs and abdomen of a spider. In addition, patients with Marfan syndrome are described as having arachnodactyly—a descriptive term for long, slender fingers.

Histologically, the term caterpillar bodies has been used to describe the linear bodies in the roofs of bullae of porphyria cutanea tarda, resembling the larvae of butterflies. In alopecia areata, the peribulbar aggregation of lymphocytes around anagen follicles has been said to resemble a “swarm of bees,” and the fragmentation of neutrophil debris in leukocytoclasis has been compared with the segmented bodies of countless ants.

The insect world is one of the most diverse biologically, and accordingly it follows that dermatologists have made a beeline for this realm when constructing memorable descriptors.

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