Laser Treatment of Postprocedural Scars

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Scars are common complications of the wound-healing process and have psychological, cosmetic, and physical implications for affected patients regardless of their origin. Despite a careful and atraumatic technique, surgical treatment and/or reconstruction can result in scarring. Every year, 100 million individuals in the United States report scarring caused by events such as trauma or surgical intervention; among them, 25 million undergo surgery immediately after the trauma and 15 million in the following months.[1] The abnormal cascade of events that leads to cutaneous scarring has been well-described. The stages of wound healing include inflammation, proliferation, and remodeling. An aberration of these events, specifically excess cellular proliferation within the wound, can result in disorganized collagen deposition as well as abnormal pigmentation, leading to an obvious scar.[2]

Scar Types

There are 3 different categories of surgical scars: hypertrophic scars (HTSs), keloids, or rarely atrophic scars. Clinically, HTSs are firm, raised, and erythematous, and are defined by an increased expression of collagen coupled with collagen lysis during the matrix remodeling phase of wound healing.[3] Hypertrophic scars usually form within the first month of initial injury and can regress over time. All HTSs remain within the border of injury.[4] Keloids are raised, dusky, nodular scars that are firmer than HTSs. Keloids extend beyond the margins of the original wound and may occur weeks to years after the initial injury. Additionally, keloids tend to affect darker skin types. Both HTSs and keloids usually affect body areas that exhibit slow wound healing or are pressure or movement dependent. Atrophic scars are dermal depressions that generally occur from collagen destruction during an inflammatory skin disease such as cystic acne; however, surgery also can result in the formation of atrophic scars.[5]

Lasers for Treatment

Scar treatment focuses on the main categories of the pathophysiology of scar formation, namely the alteration of the inflammatory response, modification of collagen metabolism, and physical manipulation of the scar morphology. When planning a treatment protocol, the primary goals should be a low recurrence rate, notable cosmesis, symptomatic improvement, and minimal adverse effects. Acceptable and efficacious nonlaser treatments of postsurgical scars include surgical revision, chemical peels, dermabrasion, and topical treatment with bleaching creams and/or retinoids.

One animal study comparing dermabrasion and chemical peels to laser resurfacing revealed that the laser modality is a more easily controlled treatment method when the desired end point is cutaneous resurfacing.[6] Currently, skin resurfacing lasers are classified as ablative or nonablative; devices then can be subclassified as fractionated or unfractionated based on whether the system utilizes fractional photothermolysis, whereby light is emitted in a pixilated fashion onto the skin to produce an array of microthermal zones or small columns of thermal injury of controlled width and depth in the dermis. The

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main difference between ablative and nonablative fractional lasers is the depth of the columns of coagulation that extend through the stratum corneum all the way to the dermis. Untreated areas between microthermal zones serve as reservoirs for wound healing. Ablative laser treatments are more severe in nature and work by vaporizing the most superficial layer of the skin to cause epidermal burning and subsequent regrowth. Recovery time can extend up to 6 weeks. Nonablative lasers are less invasive and conduct heat deeper into the dermis, essentially bypassing the top layer to stimulate collagen regrowth deep within the skin. Because nonablative lasers are less invasive, more treatments are required to achieve the best final results; however, recovery time is decreased to just days, which can be appealing to patients wishing to return to work or social activities in a timely manner. For the resurfacing potential of scars, ablative fractional lasers show a good intermediate effect when compared to overly aggressive ablative nonfractional procedures (ie, microdermabrasion or a medium-depth chemical peel) and nonaggressive nonablative fractional lasers.[7]

Ablative Lasers

The erbium:YAG (Er:YAG)(2940 nm), CO_2 (10,600 nm), and yttrium-scandium-gallium-garnet (YSGG)(2790 nm) lasers are the 3 main types of ablative lasers commonly employed for scar revisions, especially for atrophic scars. The Er:YAG and YSGG lasers are absorbed more strongly by intracellular water; however, their lower wavelengths create less residual thermal damage than the CO_2 laser. In other words, the deeper penetrating CO_2 laser can promote more collagen remodeling than the other ablative lasers because the regenerative process is positively correlated to the depth of residual thermal damage.[8,9] Multiple studies have shown the resurfacing CO_2 laser system to be a beneficial means of scar resurfacing[10-15]; for instance, in one study, 20 of 24 surgical scars receiving one laser resurfacing treatment 4 to 6 weeks following scar formation showed greater than 75% clinical improvement.[16] Additionally, elevated scars were found to improve more dramatically than depressed scars.

The short-pulsed Er:YAG laser was developed as a less-aggressive alternative to skin resurfacing with the CO_2 laser. The Er:YAG laser provides more precise cutaneous ablation, as its absorption by water is an order of magnitude greater than CO_2, thus reducing residual thermal damage.[8] Faster healing times and decreased postprocedure erythema are considered powerful evidence of the effectiveness and safety of the Er:YAG laser. In a study of 36 patients with scars that developed after simple excision procedures, 9 of 12 HTSs and 17 of 20 depressed scars showed greater than 50% clinical improvement after just one laser treatment.[17]

The YSGG laser produces greater residual thermal damage than the Er:YAG laser but less damage than the CO_2 laser, thereby preventing substantial bleeding with a decreased incidence of side effects.[18] A recent study assessed the efficacy of the YSGG laser in 5 patients who presented with scarring after hemangioma excision surgery. After 1 or 2 consecutive sessions administered 4 weeks apart, clinical improvement was seen in the majority of patients enrolled, with no side effects of ulceration, hypopigmentation, or hyperpigmentation reported.[7]

All ablative laser systems emit high-energy densities with extremely short pulses, thereby causing tissue vaporization with limited thermal conduction to surrounding skin. Each laser pass causes predictable and reproducible amounts of tissue vaporization and residual thermal damage; as much or as little tissue can be removed as required by the type of scar being treated. Deepithelialization can be achieved with a single CO_2 laser pass at 300 mJ versus 2 to 3 passes with the Er:YAG laser at 5 to 15 J/cm^2. Once achieved, the scar edges can be further sculpted with additional vaporizing laser passes.[19] Regardless of the laser that is used, the treated skin appears erythematous and edematous immediately posttreatment and worsens within the first 24 to 48 hours. Transient hyperpigmentation is another notable adverse effect that occurs early in the posttreatment course and is more common in darker skin types. Although highly effective in recontouring the skin and improving scar appearance, treatment with ablative lasers has been associated with extended recovery periods. Reepithelialization typically occurs in 4 to 7 days following treatment with the YSGG or Er:YAG lasers and 7 to 10 days following CO_2 laser treatment. Prophylactic antimicrobials should be prescribed for patients undergoing full-face procedures. Ideally, dicloxacillin or clindamycin (for patients who are penicillin sensitive) can be started along with oral acyclovir 2 days prior to the procedure and should be continued until reepithelialization is appreciated. Additionally, all topical vitamin A products should be withheld 6 months prior to starting laser treatments. Sun avoidance and sun protection also should be advised.[19]

Nonablative Lasers

Nonablative lasers are designed to cause nonfatal thermal damage, sparing the epidermis. These lasers also can operate under the principle of fractional photothermolysis

in which the laser creates zones of microthermal injury that are randomly integrated onto the skin. Within these areas, localized collagen denaturation occurs, followed by expulsion of the necrotic debris and neocollagenesis. Small islands of untreated tissue serve as an epithelial bridge to facilitate a quicker healing process. As a result, new dermal collagens are formed and tissue defects within the scar are repaired. The absence of epidermal damage substantially decreases the severity and duration of treatment-related side effects and downtime.[9]

Fractional photothermolysis using the 1550-nm nonablative wavelength (Fraxel, Solta Medical, Inc) has been cleared by the US Food and Drug Administration for the treatment of scars. Although most of the current literature focuses on using this modality for treatment of acne scarring, a recent study of 13 adults with Fitzpatrick skin types I to II presenting with postsurgical facial scars were treated once every 4 weeks for a total of 4 treatments with increasing amounts of energy level according to the patients' tolerance. A statistically significant improvement ($P<.001$) in both the patients' and observers' ratings were identified.[20]

The most common nonablative laser used in the treatment of HTSs and keloids is the pulsed dye laser (PDL)(585–595 nm), which primarily is used to reduce erythema but also has been shown to decrease scar volume and improve the texture of the scar surface.[21,22] Unlike the other lasers discussed, the PDL is believed to work mechanistically via selective photothermolysis; emitted energy is absorbed by oxyhemoglobin, generating heat and leading to thermal injury to the scar's microvasculature, which causes ischemia and reduction in collagen content within the scar. The literature on PDL for scar revision is conflicting, and the contradictory results can be attributed to differences in scar location and duration, laser setting, skin type, follow-up duration, and outcome measurement methods.[23,24] It should be noted that the most common side effect of PDL treatments is posttreatment purpura, which usually subsides in 7 to 10 days.

Summary

Laser treatment is an effective option for patients with different types of scars. The patient should be critically evaluated to correctly customize the laser treatment to the particular needs of the patient. Skin type, scar location, scar color and density, and postprocedure recovery time are important factors that the laser surgeon should take into consideration before treating any postsurgical scar. The development of nonablative fractional lasers has lowered the incidence of side effects and shortened recovery times postprocedure. Trials that place one laser modality against another or combine different laser modalities together will eventually help the clinician to determine the exact settings and number of treatments needed to achieve near-complete resolution of scars.

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thank you notes, additional paid time off, opportunities to advance or receive continuing education, opportunities to contribute in a unique role or as part of a leadership team, increased autonomy) can be intrinsic motivators that contribute most to employee satisfaction and engagement. Intrinsic rewards also are much more likely to cause your employees to identify themselves with the brand of your practice.

Creating a culture of employee engagement takes time and effort, but there is no question that the results will be more than worth it for your patients, your employees, and the overall profitability of your practice.

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