Laser Treatment of Hypertrophic Scars, Keloids, and Striae

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The successful use of the 585-nm pulsed dye laser for the treatment of hypertrophic scars has been well established over the past decade. Although 5 years ago this treatment option might have been considered as a viable choice only after all other methods failed, it is now generally recognized as an excellent first-line treatment option. Early scar treatment with pulsed dye laser irradiation effectively prevents scar formation or worsening and yields a better and more prolonged clinical improvement. The concomitant use of corticosteroids, 5-fluorouracil, or other treatments is proving to be of particular importance in reducing scar bulk and symptoms of more proliferative scars. Although optimal management for keloids and striae has yet to be determined, pulsed dye laser irradiation will no doubt continue to play a role in their treatment.

CUTANEOUS DERMAL INJURY eventuates in the inevitable formation of a scar, which may be cosmetically acceptable or unacceptable. The reparative process involves inflammation, granulation tissue formation, and matrix remodeling resulting in a variable degree of fibrosis.[1,2] In some cases, exuberant fibrosis may produce disfiguring hypertrophic scars or keloids. In contrast, endogenous factors, including mechanical skin stretching and hormonal influences, may lead to dermal dehiscence resulting in striae distensae or "stretch marks."

Hypertrophic scars, keloids, and striae have been notoriously difficult to eradicate with traditional treatments, including surgical excision, corticosteroids, and continuous wave laser destruction, yielding either unsatisfactory results or high lesional recurrence rates.[3-25] Over the past decade, advances in pulsed laser technology have enabled successful treatment of these lesions, giving millions of patients a new therapeutic option. The experimental use of the 585-nm pulsed dye laser for hypertrophic scars within port-wine stains in the late 1980s initiated a cascade of studies with this vascular-specific laser to improve the textural quality and appearance of scars.[26-32] In addition to destruction of its microvascular target, leading to decreased scar erythema, 585-nm pulsed dye laser irradiation has been shown to favorably affect scar pliability, hypertrophy, and symptoms of patient discomfort.[26,28,32] Following an initial observation of pulsed dye laser improvement of argon laser-induced scars, Alster and colleagues[26-28,32] have reported similar improvements in surgical, traumatic, acne, and burn scars. Subsequent publications by Goldman and Fitzpatrick[29,33] have corroborated these findings. Research by McCraw and colleagues[34] promoted early postoperative initiation of pulsed dye laser treatment in order to prevent scar formation or worsening in scar-prone individuals and body locations. Reiken and his colleagues[35] then definitively determined the superiority of the 585-nnm wavelength in reducing hypertrophic scar growth (Fig 1). Similarly, the 585-nm pulsed dye laser has proved useful in the treatment of striae distensae (Fig 2).[36] Factors determining patient selection, choice of laser parameters, specific treatment protocols, and management of possible adverse effects to optimize laser treatment of hypertrophic scars, keloids, and striae are reviewed in this article.

CHARACTERISTICS OF HYPERTROPHIC SCARS, KELOIDS AND STRIAE

Hypertrophic scars appear clinically as erythematous, raised, firm areas of fibrotic skin typically limited to the site of the original wound or trauma. They usually form within the first month after the inciting cutaneous injury, often becoming flatter and more pliable over time.

Keloids are even firmer, reddish-purple nodules that extend in a claw-like manner beyond the confines of the original (sometimes only slight)

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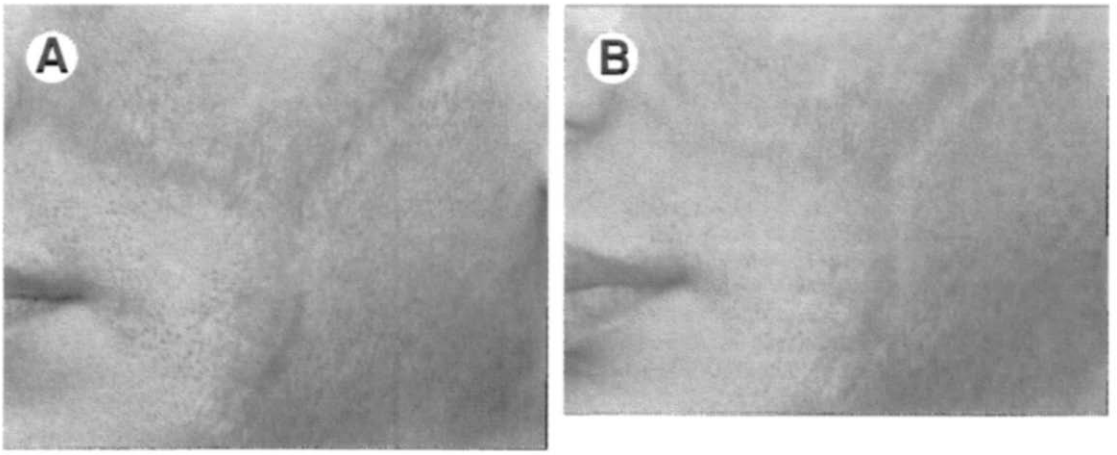

Fig 1. Hypertrophic laceration scars on the cheek (A) before and (B) 2 months after second pulsed-dye laser treatment with average fluence of 5.0 J/cm² (10-mm spot).

wound. Their development starts weeks to years after trauma (although they can arise spontaneously) and may continue to worsen for decades in extreme cases.

Both hypertrophic scars and keloids tend to be pruritic or painful on palpation and can be cosmetically unsightly. They may be a consequence of traumatic injury (eg, laceration, burn, abrasion); intentional surgical procedure (eg, excision, electrocautery, cryotherapy, laser surgery); or of vaccination or cystic acne. Their prevalence ranges from 4.5% to 16% of the population.[37] Sites of predilection include slow-healing areas (eg, anterior chest) and movement- and pressure-dependent regions (eg, scapula, shoulders, ear lobes). They occur more often in individuals with darker

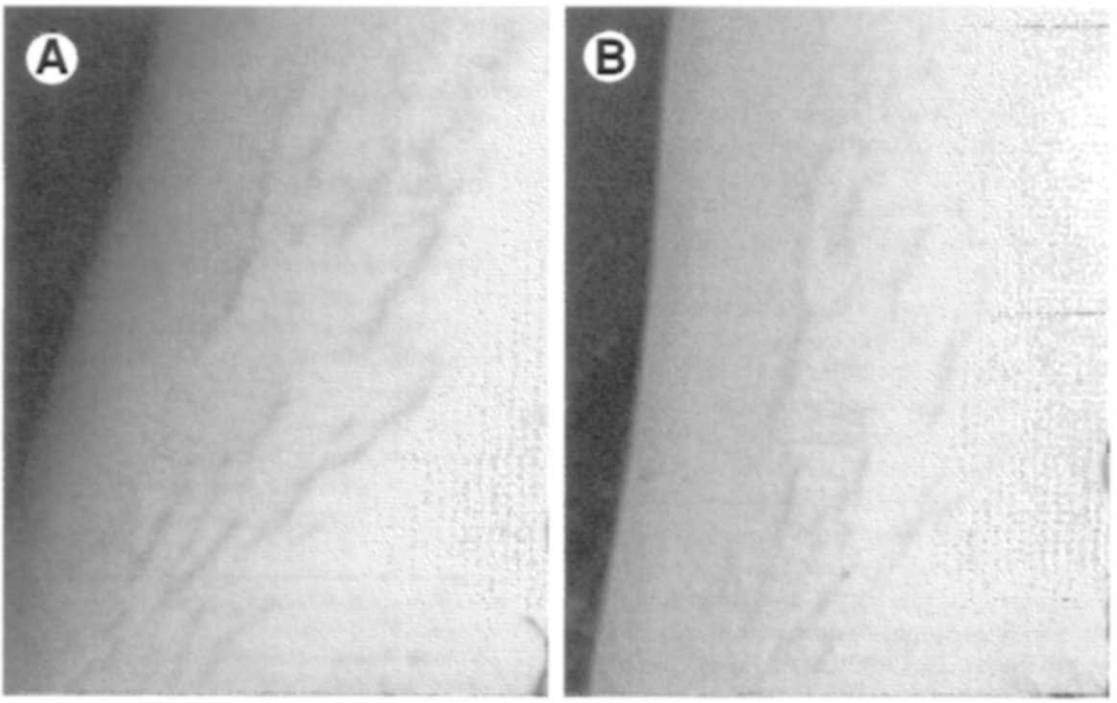

Fig 2. Striae (A) before and (B) 6 weeks after second 585-nm pulsed-dye laser treatment at average fluence of 3.0 J/cm² (10-mm spot).

skin tones and patients with impaired collagen synthesis (eg, Ehlers-Danlos syndrome). Other contributing factors to the development of hypertrophic scars and keloids include surgery performed during pubertal growth spurts, post-traumatic traction and tension, secondary infection, and foreign body irritation (eg, granulomatous response to suture material). Scar formation is a complex multistep process that is not yet fully understood, so no single cell type or factor can be made responsible for the excessive fibrosis observed. The histopathologic appearance of hypertrophic scars is characterized by whorls of young fibrous tissue and fibroblasts in a haphazard arrangement. Keloids additionally display thick, eosinophilic, acellular bands of collagen on microscopic examination.[3] The microvessels in both lesions are often occluded by an excess of endothelial cells.[38] Although keloids produce high levels of hyaluronidase, low concentrations of collagenase are typical for hypertrophic scars.[39]

Striae are linear bands of atrophic and wrinkled skin which occur after excessive dermal stretching and/or under the influence of estrogens and corticosteroids.[40-42] They become manifest after pubertal growth spurts, pregnancy, rapid weight gain, and long-term internal or external corticosteroid use. In rare cases, they may also occur after infections with typhus, paratyphus, influenza, or tuberculosis. They often exhibit scar-like features, with early striae appearing erythematous and late striae showing hypopigmentation and fibrosis. Striae are caused by connective tissue alteration following elastolysis with initial mast cell degranulation and macrophage degradation. Histologically, they are characterized by the presence of dysmorphic elastic fibers and reduced collagen fibers in the dermis.[43] The prophylactic or therapeutic use of topical agents, such as retinoic acid, has shown limited ability to change the structure and appearance of these lesions.[44,45]

LASER-INDUCED EFFECTS ON HYPERTROPHIC SCARS, KELOIDS, AND STRIAE

The positive effects of 585-nm pulsed dye laser treatment on the appearance and symptomatology of scars have been evaluated by skin surface textural analyses, erythema reflectance spectrometry readings, scar height measurements, clinical improvement, and pliability scores. Histopathologic examination of scars after laser irradiation reveals improvement in dermal collagen with finer, more fibrillar, and looser arrangement of collagen fibers.[28,32] The pulsed dye laser induces selective vascular thermal injury, leading to thrombosis, vasculitis, and gradual local repair with neovascularization.[46-48] Irradiated scars have also been shown to exhibit a large number of regional mast cells, which may elaborate a number of cytokines that could potentially stimulate the process of collagen remodeling.[28,39] It is also possible that collagen synthesis can be stimulated by dermal heat conduction from the laser-irradiated blood vessels. An additional mechanism of laser action may include selected microvascular destruction producing local tissue ischemia and the release of collagenase, leading to collagenolysis.[29]

LASER TREATMENT PROTOCOL

Patient Selection

Individuals with lighter skin tones (phototypes I and II) are the best treatment candidates because little epidermal melanin is present to serve as a competing chromophore for pulsed dye laser absorption. Patients with darker skin types can undergo pulsed dye laser treatment as well, but fluences typically need to be lowered and patients warned of the possibility of postoperative dyspigmentation. All body areas affected by keloids and scars appear to be amenable to pulsed dye laser treatment. A history carefully obtained before treatment is important because the mechanism of the injury, scar duration, and prior treatment attempts may influence treatment parameters. Previous electrocauterization, cryotherapy, and surgical excision typically produce increased tissue fibrosis, necessitating the use of higher fluences and/or a greater number of laser sessions.[49] Patients who are on anticoagulant or antiplatelet medications (eg, coumadin, aspirin) should discontinue their use before laser treatment in order to reduce the intensity and duration of postoperative purpura. Preoperative and follow-up photos are an effective way to document and control treatment progression.

Intraoperative Considerations

The laser procedure is usually performed in an outpatient setting because general anesthesia is typically unnecessary. Sufficient local anesthesia

can be achieved by the application of a topical lidocaine cream (eg, EMLA, Ela-Max) under occlusion for 15 to 30 minutes preoperatively. For the treatment of scars in more sensitive body areas, intralesional lidocaine injections and/or nerve blocks can be used. Most patients, however, require no anesthesia whatsoever. Immediately before laser treatment, any anesthetic cream and make-up should be completely removed. Hair-bearing areas within the treatment area should be protected with wet gauze. Operative personnel, patients, and accompanying persons should wear eye protection (eg, goggles) appropriate to the 585-nm wavelength being used. Flammable preparatory substances (eg, alcohol, acetone) must not be applied on cutaneous surfaces to be treated because of their incendiary potential.

Laser Parameters

Appropriate energy fluences for hypertrophic scars and keloids range from 6.0 to 7.5 J/cm^2 with the use of a 5- or 7-mm spot size, and 4.5 to 5.5 J/cm^2 with the use of a 10-mm spot. For the treatment of striae, a fluence of 3.0 J/cm^2 with a 5-, 7-, or 10-mm spot is sufficient. Single laser pulses are delivered in an adjacent, nonoverlapping manner to cover the entire scar or stretch mark (Table 1).

Postoperative Management

Purpura and mild swelling are observed after laser irradiation of scars, whereas little, if any, tissue hyperemia is seen after stria treatment. The purpura-associated color changes and swelling are at their most intense within the first 24 to 48 hours, and resolve over 7 to 10 days. The severity of these adverse effects can be limited by the application of ice packs during the first few hours after surgery. The postoperative wound care regimen involves daily gentle cleansing with mild soap and water, followed by application of a healing or antibiotic ointment and a nonstick bandage. If necessary, and once all residual hemosiderin pigmentation has disappeared and dermal healing is complete (typically 6 to 8 weeks), further laser treatment can be undertaken. The energy fluence can be adjusted to optimize clinical results depending on the tissue response to the preceding treatment session. If the previous treatment yielded noticeable scar or stria improvement, the same fluence should be used again. In instances in which only minimal or no improvement is observed, the energy should be increased by 0.5 J/cm^2.

ADVERSE EFFECTS

The most common adverse effect of 585-nm pulsed dye laser treatment is transient hyperpigmentation, which occurs most often in darker pigmented individuals and in patients who did not follow strict precautions against sun exposure. Hyperpigmentation is rarely, if ever, permanent, and the process of fading can be enhanced by application of topical bleaching agents (eg, hydroquinone or arbutin-containing compounds). Further laser treatment sessions should be delayed until all dyspigmentation has completely resolved. Prolonged erythema, vesiculation, and/or pruritus of the treatment area should raise concerns of contact dermatitis, usually to a topical antibiotic. Other possible adverse reactions, including blister formation followed by secondary infection or scar worsening, can be prevented by the use of appropriate laser parameters and avoidance of pulse overlap.

RESULTS

The majority of patients with hypertrophic scars will experience up to 80% clinical improvement after 2 pulsed dye laser treatments. More fibrotic or proliferative hypertrophic scars and keloids typically require additional treatment sessions in order to obtain the desired degree of im-

Table 1. Pulsed-Dye Laser Treatment Considerations and Protocol

Preoperative Considerations	Intraoperative Considerations	Postoperative Considerations
• Skin types I-III best	• Topical or no anesthesia usually necessary	• Topical antibiotic ointment
• Hypertrophic scars are more amenable	• Energy densities 4.5-5.5 J/cm^2 (10-mm spot) 6.0-7.0 J/cm^2 (7-mm spot) 6.5-7.5 J/cm^2 (5-mm spot)	• Sunscreen or sun avoidance
• Treatment of all body locations possible	• Deliver adjacent, nonoverlapping spots	• Evaluation for retreatment at 6-8 weeks
• No anticoagulant or antiplatelet agent use		• Consider bleaching for post-rx hyperpigmentation

Table 2. Clinical Responses of Scars and Striae to Laser Therapy

Scar Type	Laser Used	No. of Treatments Required
Hypertrophic	585-nm pulsed dye	2-4
Keloid	585-nm pulsed dye	2-6
Striae	585-nm pulsed dye	1-2

provement (Table 2). The scar qualities that show most change after pulsed dye laser irradiation include scar color, height, pliability, and texture (Fig 1).[26-28,32] Scar-associated erythema fades eventually, leaving a closer approximation of natural skin tone. Clinical observation and optical profilometry have documented diminished scar bulk with a reduction in scar height and textural improvement. Many patients appreciate the cessation of scar-related symptoms such as pruritus and burning. The high vascular specificity of the pulsed dye laser is no doubt responsible for the decreased scar erythema seen, but the nonvascular improvements may best be explained by laser-induced tissue hypoxia stimulating new collagen formation and/or controlled collagen heating, with release or stimulation of various immunofactors, resulting in enhanced collagen remodeling. Prolonged follow-up of patients 6 months to several years after pulsed dye laser treatment has revealed no scar worsening nor recurrences, further indicating the importance of this therapeutic modality.

ANCILLARY PROCEDURES

Proliferative and/or symptomatic hypertrophic scars have been observed to respond even more favorably to concomitant use of intralesional 5-fluorouracil or triamcinolone, with significant reduction in scar height and pruritus and increased clinical improvement as compared to the pulsed dye laser alone.[50,51] Hypertrophic scars that are hypopigmented and minimally erythematous also appear to do better with CO_2 laser deepithelialization, followed by pulsed dye laser irradiation,[31] whereas keloid scars may respond best to surgical excision followed by 585-nm laser treatment in order to reduce the risk of recurrence from excessive heat energy.[49]

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