Posttraumatic Laser Treatment of Soft Tissue Injury

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KEYWORDS

• Laser • Scar • Ablative • Carbon dioxide • Erbium • Pulsed dye • Fractional • Posttraumatic facial scar

KEY POINTS

- Lasers are a relatively safe and noninvasive modality in the management of posttraumatic facial scarring when used appropriately.
- Lasers exert their therapeutic effects through volumetric heating, selective photothermolysis, or frank ablation.
- Combining several lasers with or without surgical scar revision may continually improve the texture and appearance of facial scars.
- The literature regarding ideal dosimetry is mixed, and more randomized controlled trials and split scar studies may provide greater insight into the ideal management strategy based on scar type.

INTRODUCTION

Posttraumatic soft tissue injuries can result in complex, disfiguring, and often permanent scars, which may defy optimal restoration despite aggressive wound care, pharmacologic therapy, hyperbaric O_2, mechanical dermabrasion, and conventional surgery (scar revision). Whereas clean, straight lacerations may heal as well as a postoperative surgical incision, blast injuries, and penetrating and blunt trauma may result in crushed tissue, jagged wounds, and/or frank soft tissue loss leading to suboptimal closure, tension, and poor wound healing. Posttraumatic soft tissue injuries require thorough irrigation to reduce microbial burden, removal of debris to decrease risk of traumatic tattooing, proper selection of appropriate suture material, and meticulous skin closure without undue tension.[1,2] Several adjunctive measures after primary surgical management are known to reduce scar formation and improve appearance, including posttreatment dressings, silicone sheeting, isotretinoin, and dermabrasion. Although classic dermabrasion improves surface texture, contour, and, hence, the overall appearance of traumatic wounds, skin may bleed excessively during treatment, shear forces may disrupt the wound

The authors have nothing to disclose.

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Facial Plast Surg Clin N Am 25 (2017) 617–628
http://dx.doi.org/10.1016/j.fsc.2017.06.012

closure, and depth control is operator dependent, requiring skill and experience.[3]

Laser devices have revolutionized skin care and are used to treat fine rhytides, correct acne scars, manage dyschromia, eliminate vascular birthmarks, remove tattoos, and manage both surgical and posttraumatic injuries.[4–6] Lasers alter tissue based on the propagation of light through tissue, and subsequent absorption of photons with conversion to heat, photochemical interactions (photodynamic therapy), or generation of stress transients (photoacoustic waves). Clinicians have the ability to control the specific laser–tissue interaction by selecting dosimetry (pulse duration, energy density) and wavelength. Light propagates through tissue and is absorbed and scattered differentially depending on wavelength and, ultimately, this distribution of light dictates the tissue effect.[7] In the region of light distribution, if sufficient photons are absorbed, heat is generated, which may lead to a number effects, including (1) bulk volumetric heating with elevation of temperature (nonablative therapies), (2) selective photothermolysis,[5] (3) water vaporization (CO_2 or Erb:YAG resurfacing), (4) tissue pyrolysis, and (5) generation of photoacoustic transients (adiabatic heating causing stress waves as in laser lithotripsy). Photochemical modification (photodynamic therapy) and nonlinear multiphoton events, including plasma formation (keratorefractive eye surgery), also may occur, but generally have at present limited roles in the management of scars and soft tissue injury. In skin, the most widely used laser devices alter the skin via volumetric heating (nonablative techniques), selective photothermolysis (targeting of pigments such as hemoglobin or melanin), or frank ablation. Volumetric heating, such as that seen with the 1450-nm diode targets water resulting in localized heating in the upper dermis and subsequent tissue remodeling. Alternatively, lasers using selective photothermolysis, such as the pulsed-dye lasers (PDL) or Q-switched (QS) lasers work through selective chromophore targeting such as hemoglobin or exogenous pigments (ie, carbon particles), respectively, and are useful for treating cutaneous vascular malformations and tattoos.

The focus of the current review is on PDL, and ablative and nonablative resurfacing. Through the ablation process, heat generation incites inflammation and vascular permeability by inducing a pattern of thermal injury in the dermis, which stimulates complex tissue remodeling processes.[8] These treatments can be dramatic, with ablative resurfacing resulting in epidermal and superficial dermal vaporization, allowing later neocollagenesis and skin tightening. The unwanted side effects of ablative laser resurfacing (chiefly prolonged erythema and complete deepithelialization, but also third-degree burns) has been addressed through the development of alternative approaches, including nonablative and fractional laser devices.[2,8,9] Advances in fractional photothermolysis have revived the interest in both ablative and nonablative lasers in both treatment and prevention of posttraumatic scars by controlling the spatial extent of thermal injury in the upper dermis induced by the laser in both axial (in the direction of light propagation) and radial (lateral) directions. Because specifying dosimetry is the first step toward optimized therapy, controlling the spatial extent of laser-induced tissue modification has become equally as important.

Suffice it to say that many laser devices can be used to treat posttraumatic skin injuries, both acute and chronic, and there is much confusion with respect to developing a rational strategy for use. Herein we review lasers used for the management of posttraumatic facial scars and provide a flow chart (**Fig. 1**) to aid clinicians in optimizing therapy.

GENERAL TREATMENT CONSIDERATIONS

Posttraumatic skin injuries are challenging to manage, because patients may seek care either immediately after injury or even months later. Those seen acutely for example, after suture removal, may be amenable to laser treatments that may mitigate the acute inflammatory process and reduce scar formation. Patients who seek expert care long after the acute phases of wound healing may have erythematous, hypertrophic, or atrophic scars with discrete step offs, or in the case of the face, contractures compromising eyelid, nasal airway, or oral commissure function. The narrow laceration oriented along relaxed skin tension lines (RSTL) without contracture may heal well in a patient without keloid predisposition, and is generally well-suited for laser resurfacing, or no treatment at all. The challenge often lies in managing posttraumatic facial scars that were initially contaminated and insufficiently cleansed, have crushed or missing tissue, irregular wound edges, or were approximated under tension. These injuries may require classic scar revision surgery before or after laser resurfacing, because laser technology for the skin focuses primarily on optimizing surface texture, dermal remodeling, and pigmentation.

During initial scar evaluation, a thorough history should be obtained with particular attention to time