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Complications of Laser Surgery

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SYNOPSIS

- The use of lasers in dermatologic surgery has increased greatly in recent years as the development of optical technologies keeps pace with growing societal demands for safe and effective therapies that address an ever-increasing number of medical and aesthetic indications.
- As the complexity of new devices and indications for established devices increase, understanding of laser, light and radiofrequency (RF) and other energy source–tissue interactions is increasingly important to ensure patient safety.
- The development of cooling has allowed for the rapid advances of most laser, light and energy-based modalities, and remains the most important factor in preventing most complications.
- The importance of observing the immediate tissue response to any laser, light or RF energy treatment, to ensure an appropriate tissue reaction or limit adverse reactions to a single pulse whenever possible, cannot be overemphasized.
- Although complication rates remain low in the hands of properly trained clinicians, complications can happen to anyone, and knowledge of how to avoid them and how to manage them when they do occur is essential to ensure the best patient outcomes.
- Proper evaluation and diagnosis of any lesion prior to laser treatment is imperative.

INTRODUCTION

The number of treatments performed with lasers continues to grow dramatically. Innovations in optical technology and refinement of existing devices have allowed for new developments to treat patients with an ever-increasing number of medical and aesthetic indications. While lasers continue to be safe and effective in the hands of well-trained clinicians, the potential complications associated with their use are not trivial. A laser complication may be defined as any undesirable effect, even if expected, that occurs with laser treatment. In order to understand the potential complications from any laser procedure, the laser surgeon must understand basic laser principles and how these apply to specific skin structures. These principles can then be applied to gain a healthy respect and understanding of the risks inherent to any type of laser, and the importance of proper patient selection and special anatomic considerations. From here, the laser surgeon can focus on understanding the potential complications related to specific treatment indications and how to prevent and treat their occurrences. This, of course, is vital for establishing a successful laser practice and fostering a healthy physician–patient relationship.

LASER PRINCIPLES

The concept of selective photothermolysis revolutionized the development of medical lasers that could be used safely, by spatially confining thermal injury to

specifically targeted chromophores within the skin.[1] Selective absorption of light energy is dependent upon several factors, including the wavelength of light and its inherent depth of penetration, pulse duration, fluence and the optical properties of the intended target relative to surrounding tissue. Unintended thermal injury can occur when thermal injury extends beyond the target chromophore or when light is absorbed by unintended or competing chromophores, which may result in dyspigmentation, blistering and even scarring. A fundamental understanding of tissue optics (how photons are delivered to specific structural targets in the skin) and photobiologic reactions (the biologic processes that occur after a skin target absorbs light photons) is essential to prevent unintended complications associated with laser surgery.

Recent advances in optical technology have expanded the use of laser, light and RF energy sources that do not strictly adhere to the principles of selective photothermolysis. With these advances come new complications that may not be as predictable or readily detectable by observing immediate tissue responses. Such advances include the use of extended pulse durations with near infrared lasers in which a narrow therapeutic window exists for the treatment of complex vascular lesions, intense pulsed light (IPL) sources in which multiple chromophores are targeted simultaneously and may compete for desired tissue effects, and devices that target chromophores that are not spatially confined such as water surrounding dermal collagen and pilosebaceous units. Thus, immediate tissue responses within the therapeutic range are not visible and clear treatment end-points, can be difficult to predict. Laser practitioners and dermatologists should be familiar with the potential for complications with these new devices as well as their prevention and management to ensure patient safety and optimal treatment outcomes. Specific complications associated with such devices will be discussed by indication throughout the chapter.

EPIDERMAL PROTECTION

The development of skin cooling technologies that protect the epidermis from thermal injury and allow for the use of higher fluences has revolutionized laser surgery, leading to both increased efficacy and safety of laser devices.[2] The importance of adequate skin cooling with any device cannot be overstated; inadequate cooling, whether due to operator error or device failure, can lead to catastrophic injuries. Skin cooling may take three general forms: cold air convection, contact cooling or cryogen spray (dynamic) cooling, and may be applied before, during or after the laser pulse. Contact cooling includes simple application of ice packs to complex systems that pass chilled water between colorless and transparent plates. Dynamic cooling, in which a liquid cryogen is sprayed onto the skin immediately before the laser pulse, has a high heat transfer coefficient and is therefore the most efficient way of cooling the skin prior to treatment. The careful use of pre-, parallel or post-cooling for a given application is essential. While pre-cooling of skin is essential for epidermal protection prior to all laser, light and RF applications, parallel and post-cooling methods are needed with the use of long pulse durations and bulk heating of the dermis.

All methods of skin cooling have the potential for failure, whether due to device error or improper utilization. Various instances of cooling failure have been described, including infrequent application of aluminum rollers, failure of water chilling, inadequate contact, retrograde motion of copper tips and/or an inadequate cryogen spurt duration for a given spot size or fluence, that result in inadequate cooling with increased pain and undesirable tissue reactions at the time of treatment. It is important to check for properly functioning cooling prior to initiating laser treatment and to be aware of the potential for cooling failure during treatment. With the use of contact cooling, the hand piece should be checked prior to treatment to ensure that it is chilled. In the case of passive contact cooling common to many IPL devices, adequate duration of contact prior to light pulses should be ensured. Visualization of cryogen spray should be tested prior to starting treatment and should be watched for during each laser pulse. Immediate tissue reactions should be carefully observed following the initial pulse before proceeding and throughout the treatment session. Excessive intraoperative pain and deep erythema or tissue graying indicate excessive thermal injury and may be a sign of cooling failure.

GENERAL CONSIDERATIONS

Laser and operating room error

Lasers are classified as Class IV medical devices, indicating that they are dangerous to view under any condition (directly or diffusely scattered), may cause significant skin damage and are a potential fire hazard. Several general rules and entry control measures are required for Class IV lasers. These rules are summarized in the box below. Fires associated with laser devices can be prevented by minimizing exposure to anesthetic gases, supplemental oxygen, and alcohol-based products during operation. Lasers should be kept in the standby mode when not in use to avoid inadvertent firing. Persons unnecessary to the laser operation should be kept away from the laser operating area.

CLASS IV LASERS: GENERAL AND ENTRY CONTROL REQUIREMENTS

1. All personnel shall follow all applicable administrative and procedural controls.
2. Supervision directly by an individual knowledgeable in laser operation.
3. Limit entry to directly involved personnel.
4. All personnel entering the laser area should be adequately trained.
5. Appropriate laser protective eyewear must be provided for all personnel within the laser-controlled area.
6. All windows, doorways, open portals, etc., of an enclosed facility should be covered or restricted to reduce any escaping laser beams.
7. The laser must be stored or disabled when not in use.
8. The laser operating unit must have a clearly marked button that allows rapid deactivation.
9. A sign must be on the door indicating when the laser is in use.
10. Protective eyewear of appropriate wavelength is to be kept readily available outside the room, ready for use prior to entry.
11. All laser area and entryway controls shall allow rapid entrance and exit.

Ocular safety

The unprotected eye is extremely sensitive to laser radiation. The location and nature of ocular injury depends upon the wavelength used, as well as the duration and amount of incident energy exposure.[3] The primary chromophores of the eye include melanin within the retinal pigmented epithelium, the iris, sclera and choroid, hemoglobin within the retinal vasculature and water within the cornea and lens (Table 9.1). Permanent visual loss may result from laser exposure to the retinal pigmented epithelium, but other intraocular structures are also at risk for significant injury. Any potential ocular complication should be referred for ophthalmologic examination.

Wavelength-specific eye protection is imperative for both patients and operating personnel. Metal contact lenses should be used when treating periorbital skin and metal goggles for all facial treatments. The use of plastic eye shields should be avoided when treating the face due to the risk of melting. Standard goggles and plastic eye shields may not fit appropriately in infants and young children, and therefore provide inadequate protection.

Exposure to visible and near infrared light (400–1400 nm) that is absorbed by melanin within the retinal pigment epithelium may lead to partial or complete visual loss depending on the extent of injury and proximity of injury to the fovea.[3] Direct foveal injury may lead to focal scotoma as well as complete blindness, while parafoveal injury may be limited to local inflammation and edema associated with transient visual loss. Often less appreciated is the potential damage to other pigmented structures of the anterior segment including the iris and, in more darkly-pigmented individuals, the sclera. Exposure to ultraviolet and far infrared wavelengths (1400–10 600 nm) absorbed by water may lead to thermal injury to the cornea and lens. Both iris atrophy and cataracts have occurred following periocular laser hair epilation in the absence of protective eyewear. The potential for ocular injury, even with the proper use of protective eye shields, from intraocular scatter during periocular laser and intense pulsed light treatments, has been suggested and is currently under investigation.

Symptoms of ocular exposure also vary with the location and nature of injury. Injury to the cornea

Table 9.1 Ocular structures at risk for laser injury

Wavelength	Ocular structure	Chromophore	Mechanism	Associated symptoms
290–400 nm	Cornea and lens	Tissue proteins	Photochemical	Pain
400–1100 nm	Retina, iris, choroid, sclera	Melanin	Thermal	400–700 nm: color flash and afterimage >700 nm: no symptoms until significant visual loss
1400–10 600 nm	Cornea and lens	Water	Thermal	Immediate burning pain

and lens by infrared beams is associated with acute pain and burning. Exposure to wavelengths in the visible spectrum leads to an acute afterimage formation in the color complementary to the exposed beam, and may be associated with subacute ocular injury to the retinal pigment epithelium. Photoacoustic damage to the retina from Q-switched lasers may be audible at the time of exposure. Importantly, exposure to near infrared light is visually undetectable since this part of the electromagnetic spectrum is invisible. Because the retinal pigment epithelium lacks sensory innervation, extensive injury and catastrophic visual loss may occur before injury is apparent.

Patient selection

Proper patient selection and consent for treatment are fundamental to achieve successful treatment outcomes. Prior to laser treatment, it is important to counsel the patient regarding the potential side effects of treatment, the importance of the post-treatment wound-care regimen and to set appropriate expectations. Important factors to be considered include the patient's skin type, presence of tan, history of abnormal scarring, hypersensitivity, connective tissue disease, vasculopathy, pigment disorder, photosensitivity, physical urticaria, and personal or family history of vitiligo. Medications that may pose relative contraindications for laser procedures include aspirin, retinoids, tetracyclines and medications associated with dyschromias such as minocycline, amiodarone and antimalarials.

Pigmented skin inherently heals with postinflammatory hyperpigmentation, which can take several weeks to resolve. The degree and duration of hyperpigmentation can often be estimated based on the patient's history after minor injuries or procedures. Most patients are aware of their propensity for postinflammatory hyperpigmentation *once they are reminded of it*; nevertheless, it should be emphasized prior to treatment that hyperpigmentation can take up to several months to resolve.

Treatment of darkly-pigmented or tanned skin requires the use of longer wavelengths, conservative fluences and cooling to ensure epidermal protection. It is prudent to first perform a test spot prior to full treatment (Fig. 9.1). All treated areas should be sun protected following laser treatment to avoid postinflammatory hyperpigmentation. Ablative lasers (e.g. CO_2) and lasers with greater absorption coefficients

Figure 9.1 Hyperpigmentation in a patient with a darker skin type after a test spot with IPL.

for melanin (e.g. 694 nm ruby) are associated with a greater risk of dyspigmentation and should be avoided in darkly-pigmented and tanned skin.[4]

COMPLICATIONS OF LASER SURGERY

Complications associated with treatment of vascular lesions

MAJOR POINTS

- The pulsed dye laser (PDL) is generally safe and, with the use of proper parameters and technique, it has a low risk of complications.
- Purpura is the most common complication and is associated with the use of short pulse durations associated with vaporization of superficial vessels.
- The use of subpurpuric parameters has allowed for the treatment of facial telangiectasias without bruising; however, significant erythema and edema may occur.
- The use of long-pulsed near infrared lasers for the treatment of vascular lesions has a high potential for complications and should be reserved for laser experts familiar with the complexities of these lesions and devices.
- Adequate cooling is essential for the treatment of vascular lesions to avoid epidermal injury.

Vascular lasers target intravascular oxyhemoglobin, which has three primary absorption peaks (418, 542 and 577 nm), and are commonly used to treat a variety of vascular lesions including port-wine stains, infantile hemangiomas, facial telangiectasias, leg veins and other vascular and lymphatic malformations. Lasers and light sources commonly used for vascular lesions include the 585–600 nm PDL, 532 nm potassium-titanyl-phosphate (KTP), 1064 nm neodymium:yttrium-aluminum-garnet (Nd:YAG), broad-spectrum IPL sources and newer devices that use a combination of wavelengths and IPL sources.

The flashlamp-pumped PDL was the first laser specifically developed for treatment of vascular lesions based on the concept of selective photothermolysis. Newer PDL systems with extended pulse durations and pulse format allow slower, more uniform heating with little or no vessel rupture and less postoperative purpura. The PDL, owing to its superior efficacy and safety profile, remains the most commonly-utilized vascular laser. The 532 nm KTP laser is useful for treatment of superficial vessels, owing to its relatively limited tissue penetration. Long-pulsed red and near infrared lasers that target larger and deeper vessels have been used to treat leg veins. More recently, deeper components of port-wine stains, infantile hemangiomas and vascular malformations have been attempted. These complex lesions are associated with unique complications that can be serious and should be reserved for experienced laser surgeons.

Intense pulsed light devices that target both vascular and pigmented lesions have gained popularity and will be discussed separately.

Purpura

Transient purpura is one of the most common complications of vascular lesions treated with the PDL, and is due to vaporization of small capillaries and red blood cell extravasation with the use of short pulse durations. The use of purpuric parameters is often required to effectively treat port-wine stains, hemangiomas and resistant vascular ectasias. The development of newer PDL with extended pulse durations has allowed for the use of subpurpuric fluences for treatment of facial telangiectasias.[5] Treatment of purpura is usually supportive, with the use of ice, topical corticosteroids, sun protection and petrolatum if ulceration occurs.

Erythema and edema

Mild erythema and edema following the use of subpurpuric parameters is common and usually resolves within a few days following treatment. The use of pulse stacking and multiple pass techniques has increased treatment efficacy, but may be associated with post-treatment edema and erythema. Significant and more long-lasting edema has been associated with excess pulse stacking (>250 pulses) and fair skin types and can be marked in periocular skin.[6] Avoidance of excessive stacking, use of cold packs and head elevation can minimize post-treatment edema. Topical and short-course oral corticosteroids may be required for severe, prolonged cases.

Hyperpigmentation and epidermal crusting

Superficial crusting can occur with the KTP and usually lasts for 3–5 days following treatment; this is often accompanied by mild transient hyperpigmentation. Post-treatment application of petrolatum is recommended for optimal healing. Postinflammatory hyperpigmentation can be associated with excessive cooling and is more common in patients with darker skin types. Post-treatment sun protection is essential. In addition, frequency-doubled 1064 nm lasers with millisecond pulse durations have higher energy outputs and require more conservative parameters than KTP lasers that combine Q-switched pulses to form millisecond pulses.

Ulceration and scarring

Persistent hypopigmentation, ulceration, and atrophic/hypertrophic scarring may occur with the use of aggressive treatment parameters, inadequate cooling, device failure or poor patient selection. The risks of these more serious side effects may be greater with the use of red or near infrared lasers requiring high fluences. Overlapping pulses and pulse stacking should be strictly avoided with the Nd:YAG. Adequate pre- and parallel cooling is essential with the use of red and infrared lasers with long pulse durations that may lead to bulk heating of the surrounding dermis. In addition, post-cooling is useful in this setting in which large vascular targets act as heat sinks and can damage the epidermis by retrograde thermal injury. Immediate tissue reaction should be observed carefully for immediate vessel coagulation and no change in the overlying epidermis. Marked erythema or graying of the epidermis is a sign of excessive thermal injury. Ulceration and scarring have been associated with use of the Nd:YAG in the treatment of port-wine stains and hemangiomas. The potential threshold for ulceration with the use of the long pulsed Nd:YAG in port-wine stains is highly variable, particularly in light-pink lesions.[7] The use of longer wavelengths and higher fluences to treat vascular lesions may be best reserved for laser experts familiar with the complexities of these lesions and devices. Treatment with the PDL has been useful to improve atrophic and hypertrophic scarring, and is best started early in the latter case.

Dermal depressions

Dermal depressions can occur with the use of long-pulsed lasers for treatment of large facial vessels (PDL, KTP, long-pulsed Nd:YAG) and present several weeks after treatment. Such depressions may be due to spatial defects in the dermis persisting after vessel dissolution or thermal injury to surrounding collagen diffusing from the target vessel (Fig. 9.2). Dermal depressions can be seen with inadequate contact cooling, particularly in the alar groove where achieving contact is often challenging. Adequate cooling may reduce the risk of dermal depressions; however, this can occur even with use of ideal parameters. Fortunately, this complication often improves with time, but may require 3–18 months. Gentle massage can be helpful. Dermal fillers may be considered for more significant depressions that do not improve on their own.

Complications associated with treatment of benign pigmented lesions

MAJOR POINTS

- Patients presenting for treatment of any pigmented lesions should be examined by a dermatologist to ensure a proper diagnosis prior to treatment.
- Common side effects include post-treatment erythema and dyspigmentation.
- Postinflammatory hyperpigmentation is usually transient; however, it can be significant in dark skin types.
- Hypopigmentation by absorption of constitutional pigment is usually persistent and refractory to treatment.
- Treatment of melasma and postinflammatory hyperpigmentation often makes things worse following laser treatment and is not recommended.
- The use of pigment-specific lasers in the setting of vitiligo or other pigmentary disturbances may be contraindicated.

A variety of Q-switched laser systems that target melanin can be used to eliminate or lighten a variety of benign pigmented lesions. Lasers commonly

Figure 9.2 Long-pulsed Nd:YAG used to treat a port-wine stain resulting in a depressed scar.

used to treat benign pigmented lesions include the 694 nm ruby, 755 nm alexandrite, 1064 nm Nd:YAG, and IPL. Utilizing the principles of selective photothermolysis, Q-switched lasers target pigment confined to melanosomes at pulse durations that limit thermal injury to the surrounding non-pigmented structures. Due to the wide absorption spectrum of melanin, a variety of melanin wavelengths can be used that differ with regard to optical penetration depth and relative absorption of melanin. Common benign pigmented lesions, such as solar lentigines and flat seborrheic keratoses, are effectively treated with lasers. However, the potential for the use of lasers on malignant pigmented lesions is imminent given the widespread use of lasers by non-dermatologists. All patients presenting for treatment of any pigmented lesion should be examined by a physician familiar with skin cancer prior to treatment.

The Q-switched ruby laser (694 nm) is used to treat a wide variety of benign pigmented lesions including solar lentigines, seborrheic keratoses, and ephelides. Transient hypopigmentation may occur in 25–50% of patients due to the strong absorption by melanin at 694 nm. Skin crusting is common after treatment and epidermal atrophy has been reported in as many as 50% of patients treated with the ruby laser. Other side effects include tissue splatter, punctate bleeding, and edema. Permanent depigmentation and hypertrophic scarring can occur with aggressive treatment and treatment of darkly-pigmented skin. The Q-switched alexandrite laser (755 nm) also emits red light, but at a slightly longer wavelength, and carries a slightly lower complication rate. The Q-switched Nd:YAG laser emits a wavelength of 1064 nm and has been used to effectively treat dermal pigmented lesions such as melanocytic nevi and nevi of Ota and Ito.

Pinpoint bleeding and splattering

An immediate ash-white tissue response occurs at laser treatment sites with a subsequent weal-and-flare reaction that usually resolves within a few days. Punctate bleeding and tissue splatter may occur, and are more common with high fluences; nevertheless, they are generally less common than those reported with Q-switched Nd:YAG laser irradiation. The use of universal precautions is imperative. Mild blistering or clustering usually resolves within a week. Petrolatum may be applied to the area until healed.

Dyspigmentation

Transient postinflammatory hyperpigmentation and persistent hypopigmentation may occur with the use of pigment lasers in patients with dark skin types and/or tanned skin. These problems are more frequently seen with use of the ruby laser. These patients may be better suited to treatment using the Nd:YAG or limiting treatment to the specific lesion itself. Bleaching creams and sun protection may also be helpful.

Blistering, crusting and scarring

Blistering, crusting and scar formation are usually only seen with the use of excessive laser fluences, inadequate cooling and lasers with high melanin absorption in patients with dark skin. As with dyspigmentation, treatment is generally supportive with petrolatum-based products and sun avoidance. Textural changes may occur in up to 8% of patients but are generally transient and are only evident when patients are examined earlier than four weeks post-treatment.

Complications associated with treatment with intense pulsed light

MAJOR POINTS

- The complications associated with traditional lasers can also be seen with the use of IPL.
- Intense pulsed light sources emit a broad spectrum of light that targets multiple chromophores simultaneously, thus the use of appropriate fluences and cooling is essential to avoid unwanted complications.
- Patients with darkly-pigmented and sun-tanned skin have an increased risk of dyspigmentation.
- Low fluences with overlapping spot sizes are useful to minimize skip areas.
- Postinflammatory hyperpigmentation worsens with IPL treatment and should not be attempted.

Figure 9.3 Intense pulsed light used to treat a tattoo resulting in a hypertrophic scar.

The use of IPL is gaining popularity with both physicians and non-physicians for the treatment of photoaging characterized by both vascular and pigment abnormalities. While the use of cooling mechanisms, selective filters and proper patient selection have increased the safety of IPL, the potential for blistering, dyspigmentation and scar still exists. Further, sun-tanned and pigmented skin has excessive absorption properties, increasing the likelihood of IPL complications (see Fig. 9.1).

Erythema and edema

Mild pain, erythema and edema should be expected. However, when excessive they can be important signs of inadequate cooling or the need to lower fluence. Close observation of the tissue response to initial pulses is imperative to prevent serious burns. Adequate pre-cooling with good contact is essential.

Dyspigmentation

Patients with dark skin types or post-treatment sun exposure are at greatest risk for dyspigmentation. Further IPL or laser treatment should not be attempted on postinflammatory hyperpigmentation as it usually worsens. The laser surgeon must be diligent about the degree of overlap between pulses and avoid skip areas that result in prominent dyspigmentation with the use of IPL. The use of low fluences and a second pass in a perpendicular direction may minimize this complication. Topical lightening agents such as hydroxyquinone and azelaic acid may be considered.

Scarring

Scarring may occur with aggressive treatment. The use of IPL in combination with RF and laser devices may decrease the threshold for thermal injury and scarring. Lowering the energies of both light sources is prudent. As with all lasers, use for inappropriate indications can lead to complications.

Although IPL can be used to treat superficial melanocytic pigment, it should not be used to treat tattoos. Avid absorption with a poor match in pulse duration can lead to significant scarring (Fig. 9.3).

Nerve damage

Special anatomic considerations with IPL include the treatment of skin over bony prominences and the anterior neck. Transient injury to the temporal and facial nerves overlying the zygomatic arch is possible, particularly in elderly people who have thin skin and minimal facial adiopose tissue. These anatomic areas can still be treated with IPL, but lowering the energy settings may minimize this risk. Symptoms of neuropraxia, pain, and weakness

are usually temporary, but should be evaluated by a neurologist and may require treatment with carbamazepine (Tegretol). (The laser surgeon should also exercise caution when treating the neck, which has a greater risk of complications owing to its relatively thin skin. The use of lower energy settings, especially in the setting of reactive erythema, can help minimize the risk for dyspigmentation, blistering or scar.) Genital skin, that is both thinner and has darker constitutional pigment, requires use of lower fluences and adequate cooling.

Complications associated with tattoo removal

MAJOR POINTS

- Laser tattoo removal is usually well tolerated, but it usually requires several treatments.
- Hypopigmentation is usually persistent and refractory to further laser treatment.
- Postoperative wound care and sun protection are essential.
- Avoid treating tanned skin and use longer wavelengths such as the 1064 nm Nd:YAG for darkly-pigmented patients.
- When faced with a treatment-resistant tattoo switch to a different laser wavelength and avoid using greater energy densities with small spot sizes.
- Avoid using Q-switched lasers to treat patients with allergy to tattoo ink – this requires ablative methods and oral prednisone.

The most commonly-used lasers for treating tattoos are the same Q-switched lasers that are used to treat benign pigmented lesions. In general, treatment of tattoos with Q-switched lasers is well tolerated with a low incidence of serious complications. Incomplete removal and focal, persistent hypopigmentation following multiple treatment sessions are common for professional tattoos. Tattoo inks can be removed with variable success depending on the color of the ink. Purple, yellow and bright turquoise are the most difficult colors to remove. It is important to use a larger spot size and avoid using a small spot that increases epidermal injury in an attempt to clear a resistant tattoo. Resistant tattoos should be treated with a different wavelength rather than a greater energy or decreased spot size.[8] Given that tattoo ink is an exogenous substance, there are a few potential complications unique to tattoos that ought to be recognized. These include oxidation reactions, allergic reactions and the potential for ignition with treatment of firecracker or gunpowder traumatic tattoos.

Crusting and blistering

Postoperative crusting and blister formation are most commonly associated with excessive laser fluences, too small a spot size or inadvertent absorption of laser energy attributable to the increased presence of an epidermal chromophore, including darkly-pigmented skin, tanned skin or dense ink. Treatment is generally supportive with petrolatum-based products and sun avoidance. Make-up should be discouraged at this point of the healing process.

Dyspigmentation

Transient hypopigmentation occurs with most of these pigment-specific laser systems, especially with the Q-switched ruby since its shorter wavelength is partially absorbed by epidermal melanin. Transient hyperpigmentation may also occur, especially when treating darker skin phototypes. Increasing the treatment intervals (more than 6–8 weeks) decreases the incidence of hyperpigmentation in high-risk individuals.

Scarring

Atrophic and hypertrophic scarring can occur with excessive fluences relative to the amount of chromophore present. Treat hypertrophic scars with intralesional Kenalog and perform test pulses prior to attempting further laser treatment.

Allergic reactions

The use of Q-switched lasers causes a rapid thermal expansion and fragmentation of pigment-containing cells, and increased exposure to extracellular antigens which are recognized by the immune system. Various cutaneous reactions to tattoo pigment have been described, including type IV hypersensitivity

reactions to red ink (cinnabar) and photoallergic reactions to yellow ink (cadmium). Laser tattoo removal in the presence of hypersensitivity reactions should be avoided due to risks of inducing systemic hypersensitivity reactions and anaphylaxis. Ablative methods of removal, such as CO_2 or erbium:YAG (Erb:YAG) lasers, or dermabrasion may be used. Oral prednisone before and after laser treatment may be required, particularly for facial cosmetic tattoos in which eye swelling can be marked. Consultation with an allergist prior to ablative treatment may also be prudent. Intralesional or topical high-potency corticosteroids may also be used for symptomatic relief.

Paradoxical tattoo darkening

Cosmetic tattoos that contain oxides such as ferric or titanium oxide become oxidized and readily turn black upon treatment with Q-switched lasers. Colors can be mixed and it is thus best to determine the type of ink prior to treating the tattoo. If determining the tattoo inks is not possible, perform a test spot prior to treatment. Oxidized tattoos can be lightened with Nd:YAG laser; unfortunately, this is usually incomplete. Additional procedures such as surgical excision or CO_2 laser ablation may be necessary for elimination.

Complications associated with photoepilation

MAJOR POINTS

- Because photoepilation is one of the most commonly-performed laser procedures it carries a high prevalence of complications.
- Complications are influenced by skin type, body location, seasonal variations, and history of recent sun exposure.
- Mild pain, erythema and edema are common side effects and are important indicators of appropriate treatment parameters.
- Dyspigmentation, blistering, crusting and scarring are uncommon side effects associated with excessive energies, inadequate cooling and poor patient selection.
- Cooling mechanisms and longer wavelength lasers such as the Nd:YAG have allowed for safe and effective treatment of patients with darker skin types.
- Less common side effects such as paradoxical hypertrichosis, reticulate erythema, and urticarial plaques are less well understood.

Hair photoepilation is one of the most common laser procedures performed today and thus has a comparatively higher prevalence of associated complications. Many different devices are used for photoepilation, including long-pulsed red and near infrared lasers such as the 694 nm ruby, 755 nm alexandrite, 800 nm diode and 1064 nm Nd:YAG, as well as broad-spectrum IPL devices. All of these devices carry out hair photoepilation by inducing thermal injury to terminal hair follicles which results in follicular miniaturization of variable duration. Although the precise mechanism of photoepilation is not fully understood, it is thought that light within the red and infrared spectrum is absorbed by melanin in the hair shaft and within melanocytes of the hair matrix over long pulse durations, which allows for heat to be transferred to non-pigmented portions of the follicle that are critical for hair cycling. Selectivity rests upon targeting the melanin pigment in the hair follicle, which, owing to its relatively larger diameter, cools more slowly than the nearby smaller chromophores. However, unwanted light absorption by melanin within epidermal melanocytes and keratinocytes may induce thermal injury to the overlying skin which results in dyspigmentation, blistering and scarring.

Epidermal injury can be minimized with the use of contact cooling, long wavelengths that have less efficient melanin absorption and the use of long pulse durations that allow for intrapulse cooling of smaller epidermal chromophores.

The efficacy of photoepilation of hair is directly related to fluence, with greater efficacy of hair reduction occurring with the use of higher fluences. Thus, the use of higher fluences aimed at achieving a more permanent miniaturization of terminal hairs may be associated with a higher risk of side

effects. The wide array of available laser and light sources used in photoepilation differ somewhat in their efficacy and complication rates, owing to differing characteristics of optical penetration and absorption; however, the mechanisms of thermal injury are similar.

Transient pain, erythema and edema

Laser hair removal is generally a safe procedure when patients are selected properly and appropriate parameters and techniques are used.[9,10] Mild pain is expected during treatment, usually correlates with treatment efficacy and, when excessive, is an important indicator of unwanted thermal injury. Acute pain in the setting of several mildly painful pulses may indicate inadvertent vascular injury, which can occur with the use of high energies and long pulse durations with near infrared lasers. Transient post-treatment erythema and edema are also expected side effects of laser hair removal, and usually resolve within a few hours after treatment. Deeper, persistent erythema associated with the use of higher fluences may indicate excessive thermal injury to surrounding tissues. Epidermal cooling greatly minimizes the pain associated with hair photoepilation as well as thermal injury to the overlying epidermis.

Dyspigmentation, blistering and crusting

Dyspigmentation, blistering, crusting and superficial erosion occur less commonly, but, if severe, can lead to scarring. Dyspigmetation and blistering occur more commonly in patients with darkly-pigmented (Fitzpatrick skin types III–VI) and tanned skin; this is more common with the use of the long-pulsed ruby and alexandrite lasers (similar complication rates of 9–25%).[10] Dyspigmentation is less common with the Nd:YAG laser, which emits light with a longer wavelength and lower absorption of melanin and is thus preferred for the treatment of darker skin types in which epidermal melanin concentrations are higher. In addition, the use of longer pulse durations that allow for intrapulse cooling of epidermal chromophores reduces the risk of dyspigmentation.

Poor patient selection, the use of excessive fluences and inadequate cooling are the primary sources of dyspigmentation, blistering, and scarring. In addition to inadequate contact of the chilled tip and device failure, there are several complications of cooling that have been described that are specific to methods of photoepilation. These include arcuate burns resulting from inadvertent angling of the handpiece while treating curved surfaces, and ring shaped burns resulting from inadequate cryogen spurt duration relative to the spot size. The former can be minimized by diligent attention to keeping the laser perpendicular to the skin surface during treatment. A cryogen spurt duration of at least 40 ms is recommended with the use of a 15 mm spot size, and 50 ms for 18 mm. Ring-shaped burns have also been thought to occur with accumulation of debris and chilling of the guide post.

The use of contact cooling that protects the epidermis throughout the laser pulse is essential for epidermal protection, particularly with darker skin types. In addition, preoperative skin lightening may also be a useful measure to minimize the risk of epidermal injury. Performing a test spot one to two weeks prior to initiation of treatment can be helpful to evaluate the risk of dyspigmentation prior to initiation of therapy. Post-laser treatment sun protection is also crucial to avoid postinflammatory hyperpigmentation. Avoidance of irritating topical preparations such as retinoids or acne medications that may increase the risk of postinflammatory hyperpigmentation is also prudent. Nightly application of combination topical hydroquinone and hydrocortisone may be helpful in the management of postinflammatory hyperpigmentaion. More severe cases of dyspigmentation may improve with the use of superficial chemical peels. In the case of ulceration and potential scarring, postoperative wound care is essential to minimize poor outcomes. The application of petrolatum is recommended until re-epithelialization is complete.

Scarring

The risk of scarring associated with photoepilation is low with the use of proper parameters and appropriate patient selection. However, scarring can occur with the use of aggressive parameters, inadequate cooling, improper postoperative wound care, or in the event of secondary infection. Treatment with a PDL may be beneficial for both hypertrophic and atrophic scars. Hypertrophic scars should be treated

as soon as possible and usually benefit from adjunctive intralesional corticosteroids.

Paradoxical hypertrichosis, reticulate erythema and leukotrichia

Other, less common complications following hair photoepilation that should be recognized by the clinician include the occurrence of paradoxical hypertrichosis and reticulate erythema. Paradoxical hypertrichosis that occurs within and adjacent to treated areas has been described following photoepilation with several laser and IPL devices.[11] While initially thought to be rare and limited to individuals with darker skin types, paradoxical hypertrichosis has since been described in lighter skin types and is likely to be more common than initially recognized. While the mechanism is not known, this phenomenon has been hypothesized to result from aberrant follicular cycling following suboptimal thermal injury or the effects of local inflammation. Transient and persisting leukotrichia is also thought to occur following subtherapeutic injury to melanocytes within the hair matrix with no effect on follicular cycling.

Persistent reticulate erythema has also been described in patients following photoepilation with the 800 nm diode laser.[12] Striking violaceous reticular patches were observed on areas treated on the arms and legs. An unknown laser–tissue interaction involving the local vasculature is likely to be responsible. Given that six of the patients had a history of chilblains or acrocyanosis, it may be prudent to avoid laser hair epilation in this setting or possibly other collagen vascular diseases.

Urticarial-like plaques

Pruritic urticarial-like plaques have been described following laser and IPL photoepilation. Unlike urticaria, the lesions may persist for several days to weeks and may involve significant edema. Symptomatic improvement may be achieved with the use of topical corticosteroids and antihistamines.

Anatomic considerations

The use of long-pulsed red and near infrared lasers should be avoided in the periocular area due to risks of ocular injury and blindness associated with absorption of melanin within the retinal pigment epithelium as well as components of the anterior segment, including the iris. Genital and axillary skin is thin and usually carries a higher pigment index compared to surrounding skin and should be treated only with the use of conservative fluences and diligent cooling. Likewise, treatment of hair extending onto the neck area is also more vulnerable to thermal injury owing to the relative thinness of skin in this area, and often the presence of pigmentation or poikiloderma associated with increased absorption of light as well as reactive erythema in response to treatment of adjacent areas.

Inadequate or no response to treatment

While most patients with dark terminal hair growth respond adequately to hair photoepilation, some individuals have minimal or seemingly no response following treatment. The use of optimal fluences can minimize this problem; however, some patients show minimal response even with the use of appropriate treatment parameters. Greater understanding of the mechanisms of photoepilation, including the optimal treatment interval, is needed to address this problem. Managing patient expectations prior to initiating therapy can help minimize patient dissatisfaction in this circumstance.

Complications associated with ablative laser resurfacing

MAJOR POINTS

- Continuous-wave CO_2 lasers are used less frequently in clinical practice today because they produce large zones of epidermal necrosis and are associated with significant postoperative morbidity.
- Newer short-pulsed CO_2 and Er:YAG lasers lead to effective cutaneous ablation with less surrounding collateral tissue damage and shorter postoperative recovery time.
- All patients will experience some degree of postoperative erythema and edema following ablative resurfacing.
- The use of aggressive fluences, multiple passes, inadvertent pulse stacking or aggressive intraoperative rubbing all increase the incidence of edema, infection and scarring.

- Hyperpigmentation is the most common side effect, occurring in one third of patients, regardless of skin type.
- Permanent hypopigmentation may occur in fair-skinned individuals and usually appears 6–12 months following treatment.
- The risk of viral, bacterial and fungal infections requires appropriate antimicrobial prophylaxis prior to resurfacing and diligent observation during the recovery period.
- Hypertrophic scarring must be recognized early and treated promptly.

The success and complications associated with laser resurfacing for photodamaged skin and acne scarring have been well described. Advances in laser technology have simplified the procedure and minimized adverse sequelae, drawing interest from physicians across a broad range of specialties. However, while there is a great upside for the clinical outcome in treatment with resurfacing lasers, there is an equally significant side effect profile that deserves understanding by not only the provider, but the patient as well.

High-energy, pulsed and scanned CO_2 and Er:YAG lasers have generally replaced the continuous-wave CO_2 lasers that produced excessive thermal injury due to prolonged exposure of tissue to laser light energy. These newer systems emit higher fluences in short pulses, thereby limiting energy deposition to targeted sites without significant collateral thermal damage.[13] However, even when the laser procedure is carried out appropriately, many adverse reactions may occur.[14–19] Thus, it is essential that all stages of cutaneous laser ablation, including the preoperative preparation and normal recovery process, be well understood and adhered to.

Patients should have a realistic expectation and understanding of the common expected postoperative complications, as well as the signs and symptoms for the unexpected complications associated with laser resurfacing.

Erythema and edema

Postablation erythema and edema are normal and should be expected. Patients should be warned that, while this usually persists for a few weeks to months, it may persist for up to one year. The risk of prolonged erythema is increased when multiple laser passes or overlapping of laser pulses are performed, which produce greater depths of tissue injury. Treatment is usually supportive with head elevation and ice compression. For severe cases, a short course of oral corticosteroids may be necessary.

Acne and milia

Acne flares and milia formation are usually due to the use of occlusive healing ointments and dressings following cutaneous laser resurfacing. Patients with a prior history of acne are at particular risk. Treatment for mild flares of acne and milia is usually unnecessary since spontaneous resolution is commonly observed once the occlusive ointments and dressings are discontinued. For severe flares, oral antibiotics such as tetracycline may be necessary. Once the skin has re-epithelialized, milia can be treated with topical retinoic acid or manual extraction. Intralesional corticosteroids are reserved for persistent inflamed cysts.

Contact dermatitis

Contact dermatitis after laser resurfacing is a relatively common side effect of laser skin resurfacing, occurring in nearly half of patients. This is usually due to the impaired nature of the protective epidermal barrier, causing it to be more susceptible to irritation. The best way to prevent contact dermatitis from occurring is to keep the postablation regimen simple by using bland, unfragranced emollients. Encourage patients to avoid topical antibiotics or self-prescribed remedies such as herbals or other natural compounds, which may exacerbate the irritation. When an allergic or irritant contact dermatitis is suspected, all potential inciting agents must be discontinued immediately. Most reactions will clear once the offending agents are removed, but occasionally the use of topical corticosteroids and oral antihistamine may accelerate the rate of recovery and reduce the risk of scarring. Oral corticosteroids can be prescribed for severe cases.

Dyspigmentation

Transient postinflammatory hyperpigmentation is one of the most common side effects of laser resurfacing, seen in 25–33% of patients, regardless of skin type.

Nearly all patients with darker skin types will develop post-treatment hyperpigmentation. Postinflammatory hyperpigmentation following Er:YAG laser is not as persistent as that observed after multiple-pass CO_2 laser skin resurfacing. Treatment of postinflammatory hyperpigmentation includes sun avoidance and an appropriate sunscreen to prevent further exacerbation of the hyperpigmentation. Many clinicians favor using lightening agents such as hydroquinone, kojic acid, retinoic acid or azelaic acid postoperatively. Mild glycolic acid peels (30%) may also assist with pigment resolution. These should all be avoided during the first two postoperative months.

Careful preoperative screening is necessary to determine which patients are at greatest risk of developing hyperpigmentation after resurfacing. This should be screened for, and discussed, preoperatively; most patients are aware of their propensity for postinflammatory pigment changes once it is brought to their attention. Patients should regularly use sunscreens with a minimum SPF 30 for one month prior to the procedure. They should also be instructed on sun avoidance as much as possible. Patients with a suntan should not be treated. Pretreatment with topical bleaching agents such as hydroquinone and retinoic or glycolic acid has been recommended one month prior to laser resurfacing, but its clinical efficacy is yet to be proven.

Persistent hypopigmentation is an uncommon complication of ablative resurfacing that presents 6–12 months after the procedure. The risk of hypopigmentation is greatest in fair-skinned individuals and appears to be directly related to the depth of penetration and degree of thermal injury imparted on the tissue. Unfortunately, hypopigmentation tends to be more persistent than hyperpigmentation.[14,18,20] Treatment involves the use of chemical peels to help blend the lines of demarcation.

Infection

Patients undergoing ablative therapy are at substantial risk for bacterial, viral or fungal infection until the skin has re-epithelialized; this risk can be minimized by implementing a prophylactic course of antiviral, antibiotic and antifungal agents, as well as a careful wound-care regimen. Postablative infection is a potential emergency and, if it occurs, must be promptly identified and treated so as to avoid scarring, delayed wound healing, infection with other opportunistic pathogen, or dissemination.

Herpes simplex virus (HSV) is the most common and potentially devastating infection associated with laser ablation; all patients require prophylaxis prior to treatment. Postablation HSV can occur in patients who report no prior history of herpes labialis.[19,21,22] Further, patients can develop HSV reactivation following laser ablation despite proper antiviral prophylaxis, with some reports of HSV reactivation rates as high as 10%.[19,21,22]

Most symptoms of HSV present within the first week of treatment but sometimes initial findings are not evident until two weeks after the procedure.[19,21,22] Detection of a postoperative herpetic infection may be difficult because of the lack of intact epithelium. Thus, the characteristic grouped vesicles on an erythematous base may not develop on a post-CO_2-treated area that has a disrupted epidermis, and therefore the laser surgeon must be attuned to symptoms and signs of pain or a 'prickling' sensation, erosions, crusting or a superimposed bacterial infection. Although the prevention of post-treatment HSV is not absolute, early recognition is important because of the potential for delayed healing and scarring. Oral antiviral agents should be initiated 1–2 days prior to the resurfacing procedure and continued for another 10 days until re-epithelialization is complete. If a herpetic outbreak occurs despite appropriate prophylaxis, drug dosages should be increased or a change to a different antiviral should be made. In severe cases, hospital admission for intravenous antiviral therapy is necessary.

While HSV is the most common and feared postablation infectious complication, many other cutaneous infections exist. A host of infections may occur while the epidermis is disrupted, including *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, and multiple *Candida* species.[21,23] These infections are often due to excessive wound occlusion, and the moist environment of newly resurfaced skin provides an ideal medium for the overgrowth of these opportunists. Patients need to be reminded of the importance of maintaining as clean an environment as possible; even anaerobic

infections such as Enterobacteriaceae (e.g. from fecal material) have been reported.[19]

Signs and symptoms of an acute bacterial process include focal areas of persistent erythema, purulent discharge, pain, delayed healing, and erosions with crusting. If an infection is suspected, a wound culture should be performed and an empiric course of antibiotics should be initiated as soon as possible. Coverage should be broad and include activity against *Pseudomonas*. Routine antibiotic prophylaxis for all patients has been controversial;[23] however, given the consequences of infection following skin resurfacing, wide prophylaxis is prudent. Any infection is a true dermatologic emergency and requires prompt treatment to prevent scarring.

Yeast infections vary greatly in presentation from subtle changes of erythema and pruritus to pronounced changes of pustules, vesicles, and lymphadenopathy, the latter of which may delay re-epithelialization.[19,24] Patients who are prone to yeast infection should receive prophylaxis for a longer period of time than patients without such histories; even then, they may need additional antibiotic coverage.

Scarring

Textural changes and hypertrophic scarring are rare complications of cutaneous laser resurfacing; their risk can be further minimized by proper patient selection and a conservative treatment approach. High-energy fluences and excessive passes are responsible for causing excessive thermal injury and scarring.[25] Patients who experience postoperative wound infection or contact dermatitis, or those with a history of isotretinoin use within the previous six months, radiation therapy or keloid tendency are also at increased risk of scarring. Further, certain anatomic locations are more prone to scar formation, including the mandiblular skin, neck, and periorbital areas, and should thus be treated conservatively with lower laser fluences and fewer passes (Fig. 9.4).

Hypertrophic scarring requires immediate treatment by someone who is both skilled and knowledgeable in its management. Early treatment with PDL is critical and is usually accompanied by intralesional steroids or high-potency topical steroids. Repeat treatments are often necessary every 4–6 weeks to prevent scar progression.

Figure 9.4 Hypertrophic scar in a high-risk area treated with CO_2 laser in the mandibular region. Note the hypopigmentation on the cheek

Ectropion

Ectropion is another potentially serious complication following cutaneous laser resurfacing. Patients who have undergone previous lower blepharoplasty or other surgical procedures of the eyelids are at increased risk. A preoperative evaluation with a manual 'snap' test of the lower eyelid should be performed in order to determine the patient's risk of lid eversion. Lower laser fluences and fewer passes are important for infraorbital treatment to reduce the risk of scar formation and/or potential compromise of the eyelid margin. Further, the laser surgeon should look for excessive collagen contraction intraoperatively that could promote lid eversion. Treatment requires surgical correction.

Delayed wound healing

One of the most feared laser resurfacing complication is delayed wound healing. For some reason, a very rare subset of patients fail to heal for several months despite appropriate wound care and lack of infection (Fig. 9.5).[19] While there is no clear explanation for this rare complication, some believe

Figure 9.5 Poor wound healing in a patient three months post-CO_2 resurfacing; wound cultures were all negative

it may be due to injury of the epidermal appendages which compromises the new migrating epithelium.

Postoperative factors

A carefully executed postablation wound-care regimen is critical for achieving proper wound healing. No matter how well the pre- and intraoperative treatment is carried out, if the patient does not follow a strict postoperative protocol there is a great possibility for severe and long-lasting morbidity.

Many postoperative regimens after resurfacing have been described, including the open and closed wound dressing techniques. Each has its advantages and disadvantages. Many physicians opt to combine the open and closed wound-care regimen to maximize postoperative healing. The closed method is used for the first two postoperative days when the edema, serous drainage and discomfort are greatest, followed by an open technique for the remainder of the recovery period until re-epithelialization is complete. This provides the greatest patient comfort during the first two postoperative days, but allows the clinician to directly visualize the wound healing process, and thus detect and treat potential complications more effectively.

Treatment with hydroquinone should be restarted after re-epithelialization has occurred; however, treatment for longer than three months after the procedure leads to the possibility of post-treatment hypopigmentation. Once re-epithelialization has occurred, daily sunscreen is advocated, not only to protect the skin during the remainder of the wound healing process but also to maintain the benefits obtained with the laser procedure itself.

Complications associated with non-ablative resurfacing (radiofrequency and near infrared lasers)

MAJOR POINTS

- There is increasing use of non-ablative technology to achieve skin tightening and textural improvement with less postoperative morbidity.
- The lack of visible end-points with the use of RF devices and near infrared laser devices potentiates the risk of dermal and epidermal injury.
- Pain is an important indicator of excess thermal injury.
- Use of excess fluences, aggressive techniques and multiple passes can lead to epidermal and dermal burns, and dermal depressions.
- The risk of adverse effects is rare with the use of conservative fluences and multiple passes.
- Patient selection and managing patient expectations regarding modest results are important to ensure treatment satisfaction.

Non-ablative skin resurfacing is a rapidly expanding field with the goal of improving skin texture without causing the down-time and potential complications associated with ablative techniques. Monopolar RF and near infrared lasers target water surrounding dermal collagen and induce collagen remodeling through non-specific injury. The lack of visible epidermal end-points leads to the potential for excess thermal injury that may be associated with thermal burns and dermal depressions. Proper technique and adequate cooling are essential to avoid excess thermal injury. While burns may be clinically apparent by intraoperative pain and

erythema, dermal depressions appear in the weeks following treatment. Patient selection is extremely important when approaching treatment for facial rhytides and skin laxity. Deep rhytides or severe skin laxity will show little, if any, clinical response to current non-ablative skin-tightening procedures. These patients may be better served by surgical or ablative therapy.

Erythema and edema

Modest erythema and edema are the most common side effects of non-ablative skin resurfacing and skin tightening, resolving in most patients within 24–48 h. Pain, as mentioned above, is important feedback for the laser surgeon and should be monitored closely and responded to appropriately. Dyspigmentation, blistering and scarring are due to retrograde epidermal injury and are uncommon with proper technique and parameters. Use of adequate pre-, parallel and post-cooling is key in preventing excess thermal injury and limiting these complications.

Dyspigmentation, blistering and scarring

The risk of adverse events is low with the use of conservative fluences. Blistering and scarring may occur with the use of aggressive fluences and/or pulse stacking. Persistent epidermal whitening is a danger sign for blister formation. Treatment of laser-induced hyperpigmentation is usually supportive with sunscreen and emollients, as it usually improves with time.

Dermal depressions with radiofrequency devices

Dermal depressions associated with monopolar RF have resulted from selective heating of fibrous septae (heat following the path of least resistance) with the use of excessive fluences and when regional nerve blocks are used so that the patient's pain threshold cannot be assessed. Dermal depressions are usually delayed, occurring 1–2 months after treatment. This can usually be avoided with the use of lower fluences and multiple passes, as well as careful attention to the patient's pain. Mild depressions usually improve with time; massage may help. Severe depressions may require dermal subcision and the use of fillers.[26]

Caution must be used when treating areas over bony prominences such as the zygoma, mandible, and areas of thin dermis and minimal adipose tissue such as the temple and forehead. Intraoperative pain should only be mild. When using RF over bony prominences, pull the skin and treat away from the bone. Significant, unbearable pain is an important indicator of excess thermal damage and potential scarring; for this reason, regional anesthetic blocks are not recommended.

Complications associated with fractional resurfacing

MAJOR POINTS

- Fractional skin resurfacing is a promising new technology for the treatment of rhytides, scarring and dyspigmentation with improved safety and minimal postoperative morbidity compared to ablative techniques.
- The use of high fluences and multiple passes may lead to significant erythema and edema, and with aggressive techniques may be associated with persistent hypopigmentation.
- Despite the improved safety profile, fractional resurfacing is not risk free and may be associated with dyspigmentation and viral or bacterial infections in the event of significant erythema or epidermal disruption.

Fractional resurfacing is a recently described semi-ablative resurfacing technique for the treatment of rhytides, scarring and melasma. Although still rather new, fractional resurfacing is gaining popularity for its superior safety profile compared with ablative resurfacing procedures. Fractional resurfacing treats a small 'fraction' of the skin, while leaving the surrounding skin undamaged and allowing it to serve as a reservoir for more rapid tissue healing. No visible wound is created and there is minimal downtime; the technique is usually repeated every week for a total of 4–6 treatment sessions.

Aggressive treatment with an excessive number of passes becomes less fractional and may result in side effects that are more similar to ablative techniques.

Adhering to the manufacturer's recommended technique is important to minimize complications. The use of multiple passes may result in significant erythema and edema; ice packs and a short course of oral corticosteroids may be helpful. Postinflammatory hyperpigmenation may also occur. Aggressive treatment with excessive passes results in immediate tissue whitening and permanent hypopigmentation.[24] Treatment is generally supportive with petrolatum-based emollients and time. Patients with a history of HSV require appropriate prophylaxis. The use of 30% topical lidocaine may pose a risk for lidocaine toxicity if left on during treatment and should be watched for carefully. Undoubtedly, both the clinical indications for, and potential complications associated with, fractional resurfacing will become better understood as experience is gained with this laser system.

SUMMARY

Lasers are generally considered safe when used appropriately by properly trained clinicians. The development of cooling has allowed for the rapid advances of most laser, light and energy-based modalities, and remains the most important factor in preventing most complications. Most complications occur because of inappropriate patient selection, or the use of excessive fluences, number of passes or pulse stacking. Observing the immediate tissue response to any laser, light or RF energy treatment, to ensure an appropriate tissue reaction or limit adverse reactions to a single pulse whenever possible, is imperative. Although complication rates remain low in the hands of properly trained clinicians, complications can happen to anyone, and knowledge of how to avoid them and how to manage them when they do occur is essential to ensure the best patient outcomes.

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