Chapter 7

Laser Skin Resurfacing

7

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Core Messages

Ablative laser skin resurfacing:

- Significant improvement of facial rhytids, atrophic scars, and various epidermal/dermal lesions is possible with pulsed high-energy CO_2 or erbium laser tissue ablation.
- The rate of complications is related to operator experience/technique and patient variables, especially in darker skin types (Fitzpatrick skin type IV–VI).
- Transient hyperpigmentation is a common postlaser side effect that can be treated with a variety of topical bleaching or peeling agents.

Nonablative laser skin resurfacing:

- Multiple nonablative laser, light sources, and radiofrequency devices can lead to collagen remodeling and effect improvement of rhytids and atrophic scars.
- All nonablative systems incorporate a cooling device to protect the epidermis during laser irradiation. Side effects and complications of nonablative treatments are generally mild and transient and therefore can be used in all skin phototypes.
- Intense pulsed light treatments are most effective for irregular skin pigmentation and least effective for dermal collagen remodeling.
- Radiofrequency (RF) treatments are "color blind" and can be used to tighten skin and offer subtle collagen remodeling in all skin phototypes.

Contents

7.1 Introduction

The cutaneous application of laser technology was launched in 1959 with the development of the 694-nm ruby laser by Maiman [1]. Over the next two decades, the argon laser, used to treat vascular lesions, and the carbon dioxide (CO_2) laser, used to vaporize epidermal and dermal lesions, became the focus of research and development [2]. Because these lasers yielded a high rate of hypertrophic scarring and pigmentary alteration due to excessive thermal injury to dermal tissue, their use in dermatology was limited. The theory of selective photothermolysis, developed by Anderson and Parrish in the early 1980s, literally transformed the field of cutaneous laser surgery by delivery of targeted thermal energy [3]. Laser surgery has since continued to be refined and is now considered an excellent, often primary, treatment choice for a wide variety of cutaneous applications.

The laser–tissue interaction first studied by Anderson and Parrish is based on three fundamental principles–wavelength, pulse duration, and fluence. The wavelength of emitted laser light is absorbed preferentially by a selected tissue target, or chromophore (e.g. hemoglobin, melanin, tattoo ink, water). Energy density (fluence) must be high enough to destroy the target within a set amount of time, also called pulse duration. The pulse duration ideally should be shorter than the target chromophore's relaxation time (defined as the time required for the targeted site to cool to one half of its peak temperature immediately after laser irradiation). Optimization of these three parameters permits delivery of maximum energy to target structures with minimal collateral thermal damage.

The early argon and carbon dioxide lasers were continuous wave (CW) lasers, emitting a constant light beam with long tissue exposure durations, resulting in widespread thermal injury. Quasi-CW mode lasers, which shutter the CW beam into short segments, provided further refinement of this technology. As the thermal relaxation times of most chromophores are short, development of pulsed laser systems, which emit high-energy laser light in ultrashort pulse durations with relatively long time periods (0.1–1 s) between each pulse, marked a significant advancement in cutaneous laser surgery [4].

The use of lasers for aesthetic purposes has undergone exponential growth in the last decade to meet the demand for anti-aging technology. Currently, an abundance of laser and nonlaser technology exists for skin rejuvenation, scar revision, collagen tightening, and correction of cutaneous dyschromias. Treatment can be tailored to match the patient's lifestyle and desired outcome (Table 7.1).

7.2 Ablative Laser Skin Resurfacing

7.2.1 Carbon Dioxide Laser

Skin resurfacing with the CO_2 laser remains the gold standard technology for production of the most dramatic clinical and histologic improvement in severely photodamaged and scarred facial skin [5]. It was the development of high-energy pulsed CO_2 systems in the early 1990s that revolutionized aesthetic laser surgery and ushered in a new decade of rapidly evolving laser technology. Producing a wavelength of 10,600 nm, the CO_2 laser penetrates approximately 30 µm into the skin by absorption and

Table 7.1. Skin resurfacing laser and other systems. *IPL* intense pulsed light, *RF* radiofrequency, *N/A* not applicable

	System types	
	Ablative	**Nonablative**
	CO_2 (10,600 nm) Erbium (2,940 nm)	Pulsed dye (585–595 nm) Nd:YAG (1,320 nm) Diode (1,450 nm) Er:Glass (1,540 nm) IPL (515–1,200 nm) RF (N/A)
Advantages	Best clinical outcomes Single procedure	No postoperative recovery Minimal risk of side effects
Disadvantages	Prolonged recovery Increased side effects	Subtle clinical effect Multiple sessions required

vaporization of water-containing tissue. Older continuous-wave CO_2 lasers produced an unacceptable amount of thermal destruction (up to 200 µm–2 mm beyond the target area) [6]. The new generation of pulsed and scanned CO_2 lasers limit this thermal damage by delivery of high-energy laser light with tissue dwell times shorter than the thermal relaxation time of the 30 µm of targeted tissue (about 1 ms). Energy densities of approximately 5 J/cm^2 must be applied in order to achieve tissue ablation [7]. Vaporization of very thin (20–30 µm) layers of skin occurs with each laser pass, leaving a small amount of residual thermal necrosis [8]. With each subsequent laser pass, further tissue ablation occurs, but because the area of residual thermal necrosis increases (effectively reducing the amount of tissue water), the amount of ablation with each pass diminishes until a peak of approximately 100 µm is reached [9]. Delivering more than three to four passes or use of excessive energy densities significantly increases the risk of excessive thermal injury and subsequent scarring [10].

Use of the CO_2 laser for skin resurfacing yields an additional benefit of collagen tightening through heating of dermal collagen. The triple helical structure of collagen is altered, resulting in shortening of the fibers by one third [11]. Persistence of this collagen contraction results, in part, from these shortened fibers serving as a scaffold for neocollagenesis. Beyond this time, wound healing and fibroblast up-regulation of immune modulating factors leading to persistent collagen remodeling may explain continued clinical improvement seen up to 1 year after the procedure [12, 13, 14].

Several CO_2 laser systems are available and can be separated into two distinct groups: pulsed and scanned. The high-energy pulsed CO_2 lasers (e.g., Ultrapulse by Lumenis, Santa Clara, CA, USA) produce single short (1 ms) pulses of very high energies (up to 7 J/cm^2). Scanned laser systems (e.g., FeatherTouch) utilize a computerized scanning device to deliver the laser energy rapidly over the skin, thus limiting the tissue dwell time in any one area. A study comparing four different CO_2 lasers found that the pulsed systems produced the least amount of thermal necrosis with the greatest subsequent collagen formation (compared with the scanned systems), but equivalent clinical outcomes between all four lasers were observed [13].

Although techniques and applied settings vary with each patient, practitioner, and type of laser used, general principles should be followed to maximize outcome while minimizing postoperative complications. Care must be taken to avoid overlapping or stacking of laser scans or pulses in order to reduce the risk of tissue scar formation and subsequently scarring. Similarly, it is important to thoroughly remove partially desiccated tissue between each laser pass. If only a single pass is performed, partially desiccated tissue can remain intact to serve as a biologic wound dressing [15]. It is best to avoid resurfacing areas such as the neck and chest due to the scarcity of pilosebaceous units in these regions with resultant slow re-epithelialization and potential for scarring [16].

Careful patient selection is critical in optimizing outcomes from laser skin resurfacing. Non-movement-associated rhytids, especially in the periorbital and perioral areas (Fig. 7.1a–c), are very responsive to laser resurfacing whereas movement-associated rhytids, such as in the glabella and forehead areas, fail to show as dramatic a response to laser treatment. In addition to ameliorating facial rhytids, the CO_2 laser has been shown to provide tissue tightening even as much as to exert a lifting effect on tissue. Upper eyelid dermatochalasis has been shown to be significantly improved after periocular CO_2 laser skin resurfacing [17]. When used with traditional surgical lifting techniques, it enhances the overall cosmetic outcome [18]. The CO_2 laser has also been used effectively to treat atrophic and other scars [12, 19]. Sculpting of scars with the laser yields a more uniform skin texture and stimulates new collagen formation within the dermal defects. Patients can expect a mean improvement of 50–80% in moderate atrophic scars, with continued collagen remodeling and scar effacement for 12–18 months postoperatively [12, 19]. Patients with scars previously treated with dermabrasion or deep chemical peels may have additional fibrosis, which is more difficult to vaporize, thereby re-

Fig. 7.1a–c. Infraorbital rhytids and hyperpigmentation in a patient with skin phototype IV (**a**). Postinflammatory hyperpigmentation was observed 1 month following single-pass CO_2 laser skin resurfacing (**b**). Final results 1 month later with use of topical bleaching and peeling agents (**c**)

ducing their potential outcome. In addition, these patients also may have concealed hypopigmentation that could become more apparent after laser skin resurfacing [16, 19]. Although patients with paler skin tones are at lower risk for developing postoperative hyperpigmentation, those with darker skin tones can successfully undergo CO_2 laser resurfacing. Finally, and perhaps most importantly, patients must have realistic expectations of postoperative outcomes and mentally prepare themselves for the convalescence and potential for prolonged erythema and skin sensitivity.

Fig. 7.1c.

7.2.2 Erbium:Yttrium-Aluminum-Garnet Laser

Because of the potential morbidity associated with the CO_2 laser, efforts in the mid-1990s were directed at developing alternative resurfacing modalities. The short-pulsed erbium:yttrium-aluminum-garnet (Er:YAG) laser was developed in an attempt to replicate the results of the CO_2 laser while minimizing the side-effect profile. The emitted wavelength of 2,900 nm is absorbed 12–18 times more efficiently by superficial cutaneous tissues, and approximately 2–5 µm of ablation occurs per pass with equally narrow zones of thermal necrosis [20]. Clinically, this translates into a shorter postoperative healing time with much less posttreatment erythema and risk of hyperpigmentation than CO_2 lasers. However, immediate collagen contraction is only about 1–4%, and long-term collagen remodeling ranges from 0–14% [5]. Multiple passes with this laser are necessary to ablate to a similar depth as one pass of the CO_2 laser, and because the Er:YAG effects are photomechanical instead of photothermal (like the CO_2), intraoperative hemostasis is difficult to achieve [5, 21]. Therefore, the short-pulsed Er:YAG laser is limited in its utility for moderate-to-severe acne scars and photo-induced rhytids (Fig. 7.2).

Several studies have documented the effectiveness of the Er:YAG laser in the treatment of mild-to-moderate rhytids, photodamage, and atrophic scars, with the use of multiple passes, high fluences, and/or multiple sessions yielding improved clinical outcomes [22, 23, 24, 25]. The Er:YAG laser has also proven a good option for treatment of patients with darker skin types due to its lower risk of pigmentary alteration [26] and has even been used to treat melasma [27].

To address the limitations of short-pulsed systems, novel modulated systems have been developed to allow deeper zones of thermal damage and a greater level of hemostasis. Hybrid Er:YAG/CO_2 laser systems (e.g., Derma-K, Lumenis, Santa Clara, CA, USA) are capable of delivering both CO_2 energy for coagulation and Er:YAG energy for fine tissue ablation. The dual mode Er:YAG (e.g., Contour, Sciton, Palo Alto, CA, USA) combines short pulses (for ablation) with longer pulses (for coagulation). The variable-pulsed Er:YAG (CO_3, Cynosure, Chelmsford, MA, USA) system has a range of pulse durations from 500 µs to 10 ms, with the longer pulses effecting coagulation and thermal injury

Fig. 7.2a–c. Atrophic acne scars in a patient with skin phototype IV before (**a**) erbium laser resurfacing. Postinflammatory hyperpigmentation was evident 3–4 weeks after the procedure (**b**), which resolved with topical use of lightening agents and mild glycolic acid peels (**c**)

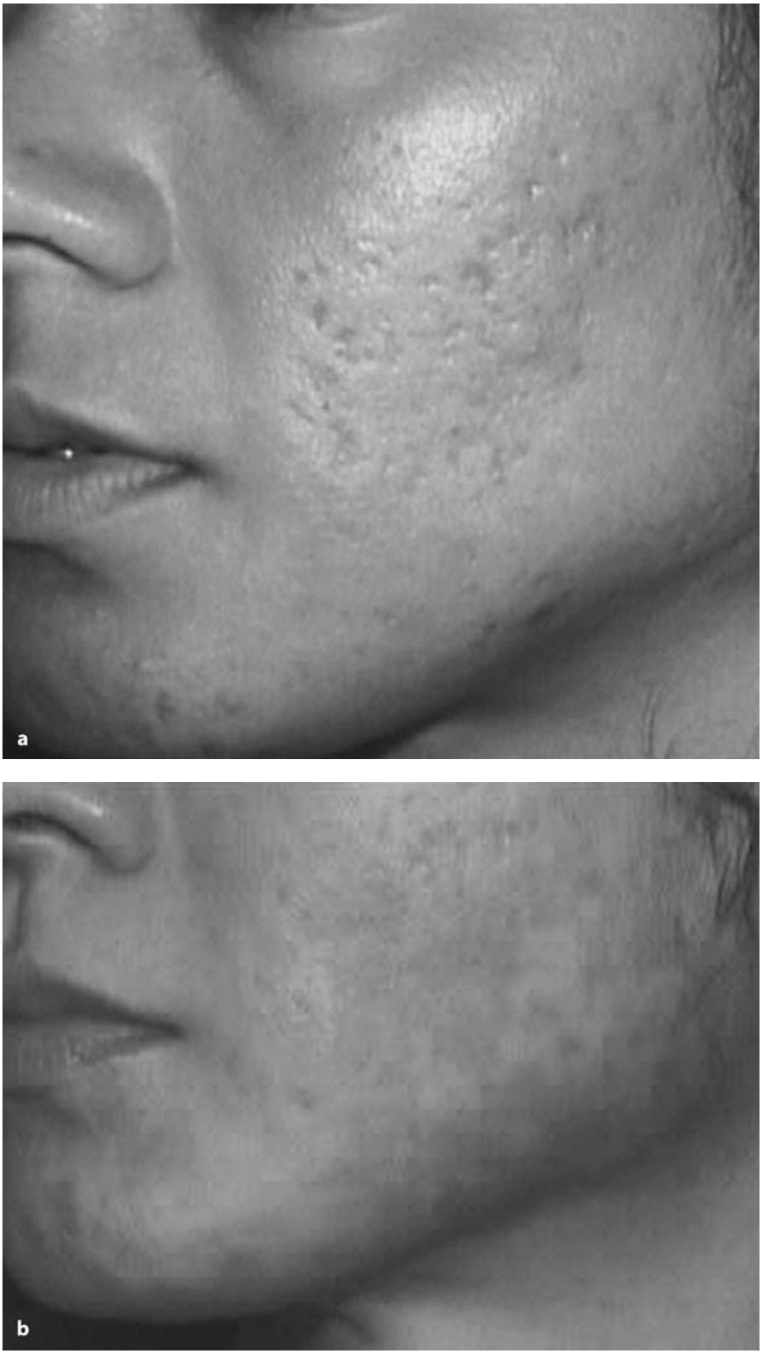

Fig. 7.2c.

similar to the CO_2 laser [28]. As a group, these lasers have been shown to produce deeper tissue vaporization, greater control of hemostasis, and collagen contraction. This translates into greater clinical improvement in mild-to-moderate acne scars and photodamage than their short-pulsed predecessors and thus represent a good compromise between CO_2 and earlier generation Er:YAG lasers [29, 30, 31, 32, 33].

7.2.3 Adverse Effects and Complications

Side effects and complications are varied and greatly influenced by postoperative care, patient selection, and operator skill. In general, the side-effect profile after Er:YAG laser resurfacing is similar but less severe and more transient when compared with those experienced after CO_2 laser resurfacing [34, 35, 36] (Table 7.2). Postoperative erythema, lasting an average of 4.5 months, is an expected occurrence in all CO_2 laser-treated patients and is a normal consequence of the wound-healing process. Erythema after short-pulsed Er:YAG resurfacing is comparably transient of 2–4 weeks duration [5, 22]. Even after the dual-mode Er:YAG laser treatment, erythema persists beyond 4 weeks in only 6% of patients [34]. Time to re-epithelialization averages 8.5 days after multipass CO_2 laser resurfacing compared with 5.5 days after Er:YAG resurfacing [5]. Hyperpigmentation is a relatively common side effect–typically seen within 3–6 weeks after the procedure. After CO_2 resurfacing, the reported incidence is 5% in the periorbital area and 17–83% in other facial sites, with an even greater incidence in patients with darker skin tones [16, 32]. Hyperpigmentation also occurs after Er:YAG laser resurfacing and is more persistent if a variable-pulsed Er:YAG is used. However, when compared with multipass CO_2 resurfacing, hyperpigmentation after dual-mode Er:YAG resurfacing resolves 6 weeks earlier [32]. Single-pass CO_2 laser resurfacing and multipass Er:YAG resurfacing, however, are

Table 7.2. Side effects and complications of ablative laser skin resurfacing

Side effects	Mild complications	Moderate complications	Severe complications
Transient erythema	Prolonged erythema	Pigmentary change	Hypertrophic scar
Localized edema	Milia	Infection, (bacterial, fungal, viral)	Ectropion
Pruritus	Acne		
	Contact dermatitis		

comparable in terms of posttreatment erythema, re-epithelialization time, and hyperpigmentation [35]. Hyperpigmentation typically fades spontaneously but dissipates more rapidly with application of any of a variety of glycolic, azelaic, or retinoic acid creams, light glycolic acid peels, and/or hydroquinone compounds. Other mild and transient side effects that have been reported during wound healing include milia formation, acne exacerbation, and irritant or contact dermatitis [5, 16, 34, 36]. Hypopigmentation, on the other hand, is long standing, delayed in its onset (>6 months postprocedure), and is difficult to treat. Fortunately, it is seen far less frequently than is hyperpigmentation. Excimer laser and topical photochemotherapy have each shown some success in repigmenting affected areas [37].

A potentially more serious complication of laser skin resurfacing is infection–viral, bacterial, or fungal. Even with appropriate antiviral prophylaxis, herpes infection (usually reactivation of latent virus) occurs in 2–7% of patients postoperatively [15, 38, 39]. While antiviral prophylaxis is commonly prescribed, the use of postoperative antibacterials remains controversial, with one study showing no significant effect of antibacterial prophylaxis on infection rate [40]. What is widely agreed upon is that patients must be followed closely during the postoperative period and placed on appropriate antibiotics if bacterial infection is suspected. If infections are left undiagnosed or untreated, systemic infection or even scarring could result [41]. Scarring has also been attributed to the use of aggressive laser parameters and/or overlapping or stacking of laser pulses, which leads to excessive residual thermal necrosis of tissue [5, 12, 16]. Improvement of these laser-induced burn scars has been affected by 585-nm pulsed dye laser irradiation, presumably by its vascular specificity as well as through stimulation of cellular mediators critical to wound healing [42].

7.3 Nonablative Laser Skin Resurfacing

While ablative skin resurfacing with CO_2 and Er:YAG lasers has been proven highly efficacious in reversing the signs of facial photoaging and atrophic scars, the associated lifestyle hindrance and potential complications are often unacceptable to patients. In recent years, focus has shifted towards nonablative technologies that deliver either laser, light-based, or radiofrequency energies to the skin. Inconsistent and often only modest clinical results are the accepted tradeoffs for a virtually nonexistent recovery period and a low side-effect profile. A myriad of systems with "subsurfacing" capabilities has been studied, including intense pulsed light (IPL) and pulsed dye, Nd:YAG, diode, and Er:Glass lasers [43, 44, 45]. Typically, a series of monthly treatments are advocated. Each treatment generates thermal injury in the dermis with subsequent inflammation, cytokine upregulation, and fibroblast proliferation [46]. Over several months, deposition of papillary dermal collagen in a parallel array occurs [45, 46].

7.3.1 Pulsed Dye Laser

Although used predominantly for the treatment of vascular lesions and hypertrophic scars [2, 47], clinical studies have demonstrated the ability of 585nm and 595nm pulsed dye laser (PDL) to reduce mild facial rhytides with few side effects [48-51]. The most common side effects include mild edema, purpura, and transient post-inflammatory hyperpigmentation. Although increased extracellular matrix proteins and types I and III collagen and procollagen have been detected following PDL treatment, the exact mechanism whereby wrinkle improvement is effected remains unknown. It has been hypothesized that the selective heating of dermal vessels leads to release of endothelial-derived growth factors and cytokines that up-regulate fibroblasts in treated skin, thereby resulting in neocollagenesis and rhytide reduction.

7.3.2 Mid-infrared lasers

Laser systems operating in the mid-infrared portion of the electromagnetic spectrum, including the 1320 nm Nd:YAG, 1450 nm diode, and 1540 Er:Glass lasers, possess optimal wavelengths for water-based non-ablative skin remodeling [52]. The majority of ultraviolet induced sun damage occurs at dermal depths of 100–400 um and, because the water absorption coefficient is low at wavelengths longer than 700 nm, infrared lasers (>1000 nm) are able to better deliver energy at these tissue depths [44].

To protect the epidermis, dynamic cooling is employed. The handpiece contains a thermal sensor to assist in maintaining the epidermal temperature below 50°C. At 40–45°C, the dermis is heated to a temperature reached of 60–65° [44, 53]. The latest generation of the 1320 nm Nd:YAG laser (CoolTouch II, ICN Pharmaceuticals, Costa Mesa, CA) delivers energies ranging 28–38 J/cm² with a pulse duration of 350 *u*s through a 10 mm spot size handpiece. Treatments are usually performed every month for a series of at least three sessions. Multiple studies have shown efficacy in the treatment of rhytides and atrophic facial scars with only mild edema and erythema post-procedure [53–57].

The 1450 nm diode laser (*SmoothBeam*, Candela Corp., Wayland, MA), which shortly followed the development of the 1320 nm CoolTouch laser, also targets water in deep dermal tissue. At the 1450 nm wavelength, lower peak powers are generated so delivery at longer pulse durations is necessary to achieve optimal fluences. For epidermal protection, tissue cooling is applied at brief intervals before, during, and after laser exposure [58]. In recent clinical trials, the *SmoothBeam* laser was shown to be effective in the treatment of facial and neck rhytides, acne, and atrophic scars [58–62]. Periocular rhytides, in particular, appear to be most amenable to 1450 nm diode laser irradiation, with marked clinical improvement observed after a series of four treatments [58, 59]. Fluences used for treatment ranged 12 to 14 J/cm² with a 6 mm spot. Maximal clinical improvement is delayed for 6 months after the series of treatments, presumably because of slow collagen remodeling and synthesis.

A study comparing the 1320 nm Nd:YAG to the 1450 nm diode laser for treatment of atrophic acne scars revealed that the 1450 nm laser effected more significant change in the scar appearance and skin texture [57]. Both mid-infrared lasers, however, induced clinical improvement. With the additional positive effect of the 1450 nm diode laser on active acneiform lesions [62], this system may be preferable for those patients with concomitant acne and atrophic facial scars.

Like the two aforementioned infrared lasers, the 1540 nm erbium-doped phosphate glass (erbium glass) system targets deep dermal water but is least absorbed by melanin, offering a potential advantage to the other nonablative lasers when treating darker skin types. The 1540 nm erbium glass laser has been used successfully to treat facial rhytides at 10 J/cm through a 4 mm collimated beam (Aramis, Quantal Medical, France) [63,64].

7.3.3 Intense Pulsed Light Source

Several investigators have shown successful rejuvenation of photodamaged skin after intense pulsed light (IPL) treatment [65–67]. The IPL source emits a broad, continuous spectrum of light in the range of 515 nm to 1200 nm. Depending on the clinical application, cut-off filters are used to eliminate shorter wavelengths, with shorter filters favoring heating of melanin and hemoglobin. Improvement in skin coarseness, irregular pigmentation, pore size, and telangiectasia is typical after a series of IPL treatments (fluences 30–50 J/cm²), however, neocollagenesis and dermal collagen remodeling with subsequent improvement in rhytides following treatment has been more modest. The mild effect on dermal collagen is thought to be induced by heat diffusion from the vasculature with subsequent release of inflammatory mediators stimulated by vessel heating [68].

7.4 Nonablative Radiofrequency Technology

The latest device to be initiated for non-ablative skin treatments involved radiofrequency (RF) technology. Unlike laser or light sources, which generate heat when selective targets, such as

Fig. 7.3a,b. Perioral rhytides in a patient with skin phototype II before (**a**) and after (**b**) the third nonablative 1,320 nm Nd:YAG laser treatment

microvasculature, absorb photons, the radiofrequency device delivers an electric current that nonselectively generates heat by the tissue's natural resistance to the flow of ions. As melanin absorption is not an issue, this RF device can be safely applied regardless of skin type. Radiofrequency technology has previously been used for aesthetic cutaneous surgery, albeit for a limited time and with equivocal results. High frequency, low voltage energy was delivered through conducting media for epidermal ablation (cold ablation) [69,70]. Reconfiguration of this technology resulted in the ThermaCool TC™ System (Thermage, Inc., Hayward, CA), which has a unique treatment tip with a coupled electrode design that allows for uniform volumetric heating of the deep dermis. To prevent epidermal ablation, cryogen spray cooling is delivered prior to, during, and after the emission of radiofrequency energy.

Fig. 7.4a,b. Atrophic acne scars in a patient with skin phototype III/IV before (**a**) and after (**b**) three consecutive monthly nonablative long-pulsed 1,450-nm diode laser treatments

Heating of the deep dermis and subcutaneous tissue occurs; with the depth determined by treatment tip geometry and the impedance levels in varying tissues (as opposed to wavelength with laser irradiation). Heat-induced collagen denaturation and contraction account for the immediate skin tightening seen after treatment [67]. As with all other non-ablative devices, further neocollagenesis takes place over the ensuing months, effecting further reduction of rhytides and tissue tightening [71–74] . Periocular rhytides and brow rhytides have shown significant improvement after a single treatment, as have cheek and neck laxity [71–74]. Maximal clinical results are observed 3 to 6 months after treatment and additional treatments can be applied for additive effect [74].

7.5 Adverse Effects and Complications (Non-Ablative Lasers/ Radiofrequency)

Side effects of non-ablative lasers and radiofrequency treatments are generally mild and transient. Local erythema and edema are typically observed in treated skin; however, a small percentage of patients in these studies experience superficial burns, ecchymoses, dysesthesias, and vesiculation [59, 71–74]. Mild to moderate discomfort which intensifies at higher fluences is typical despite the use of topical anesthesia and tissue cooling techniques, thereby leading many practitioners to add oral sedation and/or anesthetic nerve blocks.

7.6 Conclusion

Skin remodeling using ablative and nonablative laser and other technologies is an area of continued growth and evolution. Further refinement of technology will serve to enhance clinical outcomes whilst minimizing side effects. Nonablative procedures for rhytides, scars, and tissue tightening offer a variable degree of improvement over a 3 to 6 month period. Results after treatment will disappoint patients who desire dramatic improvement in a short period of time. Additionally, although these technologies have a much lower side effect profile, they are not devoid of risks. For patients with frequent oral herpes outbreaks, antiviral prophylaxis should be considered prior to treatment with any laser or light source application due to possible viral activation. Patients with darker skin tones are at higher risk of hyperpigmentation after treatment with many lasers and light sources, therefore fluences and cryogen spray times should be adjusted accordingly and patients should be forewarned of this reversible complication.

7.7 Summary

Ablative laser skin resurfacing has revolutionized the approach to photodamaged facial skin. Technology and techniques continue to evolve, further enhancing the ability to achieve substantial clinical improvement of rhytides and dyspigmentation with reduced postoperative morbidity. Utilizing proper technique and treatment parameters, excellent clinical results can be obtained with any one or combination of CO_2 and Er:YAG laser systems available. Therefore, the best choice of laser ultimately depends on the operator's expertise, clinical indication, and individual patient characteristics. Regardless of the type of ablative resurfacing laser used, the importance of careful postoperative follow-up cannot be overemphasized.

For those patients who desire a less aggressive approach to photorejuvenation, non-ablative dermal remodeling represents a viable alternative for patients willing to accept modest clinical improvement in exchange for ease of treatment and a favorable side-effect profile. Treatments are typically delivered at monthly time intervals with final clinical results taking several months after laser irradiation to be realized. Although clinical outcomes with these non-ablative systems are not yet comparable with those of ablative CO_2 or Er:YAG lasers, they do improve overall skin texture, tone and elasticity – subjective findings often difficult to represent in photographs. None of the non-ablative laser systems has yet emerged as being clearly superior – each produces similar degrees of improvement in dermal pathology after multiple sessions at standard treatment parameters. With continued research efforts focused on non-ablative laser skin remodeling, it is possible that further refinements and advances in this technology will more closely approximate the effects of ablative laser treatment without its associated complications and risks.

Fig. 7.5a,b. Cheek and neck skin laxity before (**a**) and after (**b**) a single radiofrequency skin treatment

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