Noninvasive Facial Rejuvenation. Part 3: Physician-Directed—Lasers, Chemical Peels, and Other Noninvasive Modalities

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Abstract

A proper knowledge of noninvasive facial rejuvenation is integral to the practice of a cosmetic surgeon. Noninvasive facial rejuvenation can be divided into patient- versus physician-directed modalities. Patient-directed facial rejuvenation combines the use of facial products such as sunscreen, moisturizers, retinoids, α -hydroxy acids, and various antioxidants to both maintain youthful skin and rejuvenate damaged skin. Physicians may recommend and often prescribe certain products, but patients are in control with this type of facial rejuvenation. On the other hand, physician-directed facial rejuvenation entails modalities that require direct physician involvement, such as neuromodulators, filler injections, laser resurfacing, microdermabrasion, and chemical peels. With the successful integration of each of these modalities, a complete facial regimen can be established and patient satisfaction can be maximized. This article is the last in a three-part series describing noninvasive facial rejuvenation. Here the authors review the mechanism, indications, and possible complications of lasers, chemical peels, and other commonly used noninvasive modalities.

Keywords

- ▶ noninvasive facial rejuvenation
- ▶ laser
- ▶ microdermabrasion
- ▶ chemical peel

The quest to preserve a youthful appearance has persisted for centuries, and recent advances in dermatology have catalyzed the re-emergence of noninvasive techniques. Neuromodulators and fillers have become popular over the years. However, other noninvasive modalities such as lasers, chemical peels, and microdermabrasion remain viable alternatives to successful noninvasive facial rejuvenation. Here we detail the proposed mechanisms for the various technologies and discuss their indications and potential complications.

Lasers

Historical Perspective and Basics

The laser, an acronym for light amplification by stimulated emission of radiation, is employed for a variety of medical indications. Lasers have been a component of the treatment

repertoire since the late 20th century, commencing with the development of the first laser by physicist Theodore Maiman.¹ Less than a decade later, carbon dioxide lasers found clinical application in the treatment of wrinkles and acne scars given its ability to vaporize intracellular water.²

Light amplification underlies the basic science of lasers. Atoms in a lasing medium are stimulated to release photons, or electromagnetic radiation. A system of mirrors at each end of the laser reflects the photons from the lasing medium back onto the lasing medium, resulting in the generation of more photons in a process called light amplification. The emerging laser beam is monochromatic (one wavelength), unidirectional, and coherent (in phase in space and time).³ The wavelength of the photon determines its energy (measured in Joules) and can be adjusted depending on the desired clinical use.

Lasers can be adjusted to target specific tissues of various cutaneous depths depending upon absorption and scattering profiles of the tissue of interest. The desired effects of lasers are attained when tissues absorb the light energy. Endogenous chromophores (primarily water, melanin, and hemoglobin) in the target tissue have wavelength absorption profiles and determine the degree of light absorption. The different lasers will target these chromophores with varying effectiveness and specificity. The extent of light scattering is inversely proportional to the wavelength of light, thus the depth of laser energy penetration increases with wavelength. This holds true until the midinfrared region of the electromagnetic spectrum, upon which light penetrates more superficially due to increased light absorption by tissue water.⁴

Selective photothermolysis, a technique pioneered by Anderson and Parrish, is a process by which selective cutaneous structures can be destroyed without damaging surrounding structures. The technique is based upon the selective absorption of a brief radiation pulse that generates and confines heat within a selected pigmented target.⁵ To both target the appropriate tissue and minimize undesired damage, the wavelength of the applied laser should match the absorption profile of the tissue of interest, and the duration of exposure, or pulse width, should be shorter than the thermal relaxation time of the target. Additionally, the energy must be sufficient to destroy the target tissue within the appropriate time interval.^{4,5} These basic principles guide the selection of lasers appropriate for specific cutaneous targets and lesions.⁴

Other parameters that must be carefully picked by the surgeon are the spot size, pulse duration, and pulse delay. A larger spot size can slightly increase the depth of penetration and reduce scattering; however, it also becomes harder to focus on small lesions with a large spot. Before discussing pulse duration and pulse delay, fluence and thermal relaxation time must be defined.

Fluence is simply energy divided by area. Threshold fluence is the highest energy per area that is allowed without tissue destruction. Thermal relaxation time is the time it takes for tissue to cool down 50%. Now pulse duration and pulse delay must be adjusted to ensure that the cumulative energy of repeated pulses does not rise above the threshold fluence, and the tissue has adequate time to cool down between pulses.

Specifics and Indications

Lasers are often characterized by their lasing medium and mode of light emission. Multiple lasing media are utilized and include solid-state, gas, excimer, dye, and semiconductor. Continuous wave (CW) lasers produce a continuous beam of light, and nonselective tissue damage may result from the extended exposure durations. Quasi-CW lasers also produce a continuous beam of light, but this beam is mechanically shuttered into short-exposure intervals. Pulsed lasers emit high-energy light in pulse durations of varying lengths, ranging from long pulsed to short pulsed to quality-switched (QS). These Q-switched lasers are excellent tools for densely pigmented lesions or tattoos.⁴ An overview of the different types of lasers is provided in **Table 1**.

Four major resurfacing laser platforms with dermatologic applications include ablative and nonablative lasers of both the fractionated or nonfractionated type. Ablative lasers vaporize tissues and are more aggressive than the nonablative lasers that leave tissue intact.⁶ The nonfractional laser classes act upon the entire projected surface area of the treated skin, whereas the fractionated lasers are more selective and create microthermal treatment zones that are surrounded by intact tissue.⁷ Using pixels of an image as an example, nonfractionated devices treat every pixel, whereas fractionated lasers affect a percentage of the pixels in the treatment area.⁶

Ablative, nonfractionated skin resurfacing is accomplished with lasers that emit photons targeted for absorption by water molecules in the skin, resulting in destruction of the epidermis, papillary dermis, and, sometimes, the reticular dermis. This promotes collagen synthesis, tissue remodeling, and re-epithelialization of the target area.⁸ Subsequent dermal and epidermal retraction tightens the skin.⁶ The CO₂ laser and erbium:yttrium-aluminum garnet (Er:YAG) laser are two prototypical ablative lasers.

Traditional CO₂ lasers emit photons with a wavelength of 10,600 nm. High-pulsed and scanning CW lasers allow for greater control of thermal damage and depth of ablation.⁹ CO₂ laser systems are most effective for alleviating facial wrinkles, acne scars, and atrophic scars.⁶ Fine wrinkles, especially those around the eyes or mouth, exhibit greater improvement than deeper rhytides and creases.⁹ Both scanning CO₂ lasers and pulsed CO₂ lasers have produced similar results, side effects,

Table 1 Common types of lasers

Laser name	Wavelength (nm)	Primary chromophore	Indications
Ruby	347	Melanin	Tattoos
Alexandrite	750	Melanin	Tattoos
Intense pulsed light	400–1200	Melanin and hemoglobin	Rosacea, vascular lesions, acne, red tattoos
ND:YAG	1,064, 1,320, 1,540	Water	Hair removal, deep hemangiomas, black and green tattoos, nevus of Ota
Diode	1,450	Water	Hair removal, darker tattoos
Er:YAG	2,490	Water	Skin lightening and leveling
CO ₂	10,600	Water	Deep rhytids, sun damage, skin tightening, hypertrophic burn scars

Abbreviations: Er:YAG, erbium:yttrium-aluminum-garnet; ND:YAG, neodymium-doped yttrium-aluminum-garnet.

and histological differences.¹⁰ The main side effect of non-fractionated CO₂ lasers is skin hypopigmentation that correlates with the amount of tissue injury induced by the laser, but hyperpigmentation may also occur.⁶

The Er:YAG lasers emit light in the infrared range with a wavelength of 2,940 nm. Water molecules absorb this wavelength more efficiently, resulting in a more superficial depth of penetration and less nonspecific damage to surrounding structures.⁸ Er:YAG lasers have similar indications as CO₂ lasers, but the CO₂ laser is often considered superior.⁹ However, a recent comparison of resurfacing and fractional lasers in the treatment of acne scars demonstrated that Er:YAG lasers were as effective as CO₂ resurfacing lasers, but were associated with shorter social downtime and fewer adverse effects.¹¹ The Er:YAG lasers produce less discomfort, erythema, and edema and are associated with shorter healing times. Notably, bleeding increases with the successive use of the Er:YAG laser, as it lacks the ability to photocoagulate blood vessels like the CO₂ lasers.⁹

Ablative lasers produce the most dramatic outcomes and remain the treatment of choice for several lesions.⁶ The two most common indications for ablative laser therapy are photoaging and scarring. Photoaging encompasses the following changes: dyspigmentation, rhytides, actinic keratoses, and vascular changes.⁷ Laser resurfacing effectively improves the appearance of acne, and traumatic and surgical scars.⁹ Ablative lasers are associated with prolonged recovery time, as the skin's superficial layers are completely destroyed, and carry significant risk of scarring, discoloration, and infection.⁶

Nonablative laser systems induce dermal collagen remodeling by acting on water as the primary chromophore. However, they target water less specifically than ablative systems and exhibit variable absorption by hemoglobin and other pigmented molecules. As a result, nonablative lasers selectively affect the dermis without disrupting the overlying epidermis.⁸ Nonablative laser platforms are preferred for more moderate defects,⁶ and lasers of varying wavelengths, typically in the midinfrared spectrum, are used to improve acne and related scarring, skin texture, wrinkles, and dyspigmentation.^{6,12} Nonablative lasers do not induce the pigmentation changes that often arise with ablative laser use; therefore, their use is preferred in patients with darker skin complexion.⁶ Nonablative approaches have fewer side effects and shorter recovery times, but produce subtle changes and often require multiple treatment sessions to achieve desired results.¹² A variety of traditional, nonablative laser devices exist including the 1319-nm pulsed energy laser, 1320-nm neodymium-doped yttrium aluminium garnet (Nd:YAG) laser, and the 1450-nm diode laser.

Nonablative, fractionated lasers provide a gentler treatment approach to many skin lesions. Treatment results in moderate improvement and moderate downtime, but like other nonablative approaches, multiple treatment sessions are often necessary.^{6,8} Clinical uses include texture improvement, mild to moderate wrinkles, acne scarring, and hyperpigmentation secondary to aging or sun damage.⁶ Pain frequently accompanies treatment and may be managed with topical anesthetics. Examples include the 1410-nm

diode laser, the 1440-nm Nd:YAG laser, the 1550-nm Erbium glass laser, and the 1927-nm thulium fiber laser.⁶

Ablative, fractionated lasers retain resurfacing power, but the fractionated component reduces trauma to surrounding tissues. Both the CO₂ and Er:YAG lasers have fractionated counterparts. They are safer than nonfractionated ablative lasers, but still possess significant risk of scarring, discoloration, and skin infection. Mild skin tightening is the main indication for the use of these lasers, but photodamage, scars, and rhytides are also effectively treated.⁶ Multiple treatment sessions may be required to achieve clinically significant improvement.⁷ Compared with ablative, nonfractionated approaches, moderate downtime and moderate risk of infection should be expected.⁶

Another nonablative approach, pulsed dye lasers (PDLs) use organic dyes (i.e., rhodamine 6G) as the lasing media.³ Therapy with a PDL is efficacious in treating many dermatologic conditions, but has emerged as a workhorse in the management of vascular lesions. PDL therapy can improve the appearance of port-wine stains, facial telangiectasias, hemangiomas, pyogenic granulomas, and Kaposi's sarcoma. Additionally, hypertrophic scars, keloids, striae distensae, lymphangiomas, and angiofibromas may be amendable to PDL. Therapy with a PDL is commonly complicated by post-operative purpura and transient depigmentation, but rarely vesiculation and scarring may occur. Setting the fluence to 5 to 10 J/cm² and minimizing pulse overlap can help reduce thermal injury. Longer wavelengths and extended pulse durations allow for deeper tissue penetration and typically improve clinical outcomes.⁴

Intense pulsed light (IPL) is another therapy used by surgeons and dermatologists for the treatment of rosacea, acne, and vascular lesions. Intense pulsed light is technically not a laser because it is not monochromatic and carries a variety of wavelengths. However, it is treated like a laser, often replacing the pulsed dye laser in many clinical settings. The wavelengths used can be adjusted at every use, depending on which chromophore the surgeon wishes to target with each treatment. It is also very effective in targeting the red color that other lasers miss which make it useful for rosacea and vascular lesions. There is not much recovery time, however, multiple treatments are oftentimes needed for an adequate and long-lasting effect.¹³

Microdermabrasion

Microdermabrasion is a minimally invasive cosmetic procedure consisting of two components: an abrasive component and a vacuum component. An inert crystal like aluminum oxide or sodium chloride is accelerated from the handpiece toward the skin. The interaction between the skin and crystals creates a gentle mechanical abrasion that removes the superficial layers of the skin. The spent crystals and skin debris are then collected by the vacuum and deposited in a waste receptacle.¹⁴

Mechanical abrasion is thought to stimulate dermal collagen and elastic fiber production. Additionally, microdermabrasion treatments may elicit an inflammatory response in the

dermis and epidermis that resembles a reparative process.¹⁵ Histologically, skin thickening via an increase in epidermal thickness and collagen reorganization has been visualized.¹⁶ These changes are thought to contribute to the beneficial clinical effects demonstrated after multiple microdermabrasion treatments.

The operative depth and degree of mechanical abrasion is dependent upon multiple factors including the strength and flow rate of the crystals,¹⁷ the number of passes performed over a region of skin,¹⁷ vacuum pressure,¹⁶ and force applied by the operator.¹⁶ Some believe that higher levels of abrasion produce better results, so they maximize crystal outflow pressures. However, outflow pressures and vacuum suction may need to be decreased over areas of thin skin to avoid injury.¹⁷

Microdermabrasion therapy has been advocated for treatment of photoaging (i.e., wrinkles, dyspigmentation), acne, acne scars, and striae distensae.¹⁷ Multiple authors have investigated the clinical effects of microdermabrasion on skin contour irregularities. Early studies demonstrated the clinical benefit of subjecting acne scars to aggressive microdermabrasion treatments.¹⁷ Coimbra et al found that patients receiving weekly microdermabrasion treatments for a total of eight treatments reported subjective improvement in rhytides, though plastic surgery-associated observers did not note this improvement.¹⁶ Another study demonstrated a significant improvement in fine wrinkles and overall skin texture, tone, and appearance after weekly microdermabrasion for a total of six treatments.¹⁸ Overall, it appears microdermabrasion is capable of inducing production of collagen and other matrix components that may fill in superficial contour deformities such as fine wrinkles, acne scars, and striae distensae.¹⁷

The evidence supporting the efficacy of microdermabrasion for acne vulgaris and dyspigmentation disorders (i.e., melasma, mottled hyperpigmentation of photoaging) is less definitive. It is hypothesized that the abrasion and vacuum components of microdermabrasion may remove follicular plugs and hyperkeratosis, resulting in clinical improvement of acne.¹⁷ In one study, acne appearance did not show significant improvement after microdermabrasion therapy, though baseline acne in the patient population was mild.¹⁸

Laser therapy has been shown to be just as effective in treating acne with or without microdermabrasion.¹⁹ Moreover, a level V study reported that most patients with acne treated by microdermabrasion worsened with treatment, but improved after institution with medical therapy.¹⁷ As such, the current body of literature does not support the use of microdermabrasion as an appropriate therapy for acne vulgaris.

Multiple authors have evaluated the effect of microdermabrasion therapy on dyspigmentation disorders (i.e., melasma, mottled hyperpigmentation of photoaging). Microdermabrasion therapy may improve hyperchromia and mottled hyperpigmentation, though results are conflicting.^{16,18} Modest improvements should be expected, with one studying quoting a 5 to 15% improvement.²⁰ In a split-face study comparing the effects of microdermabrasion and glycolic peels, patients generally found glycolic peels superior in terms of skin color improvement.²¹ The evidence does not definitively support microdermabrasion as therapy for dyspigmentation; therefore, other treatments are often considered ahead of microdermabrasion.¹⁷

Microdermabrasion procedures are relatively low-risk and associated with few adverse outcomes. However, multiple repeat procedures are often necessary to achieve modest improvements. Erythema and mild pain are common, and minor abrasions may result from aggressive procedures. Patients with thin, photodamaged skin or those taking antiplatelets may develop petechiae. The risk of postprocedure dyspigmentation and scarring, commonly encountered with laser therapy, is minimal.¹⁷ Surgeons should consider microdermabrasion in the risk-averse patient who will tolerate multiple treatment sessions.

Chemical Peel Skin Resurfacing

Chemical peeling is a topical tissue resurfacing regimen for facial rejuvenation (→Table 2). Chemical peels contain carboxyl or hydroxyl functional groups that disrupt portions of the epidermis and/or dermis, inducing immunohistological features resembling wound healing.²² Varying strengths of acids are utilized, inducing changes ranging from decreased keratinocyte adhesion and sloughing to direct cytotoxicity. The depth of damage is dependent upon multiple variables

Table 2 Indications and complications of chemical peel procedures

Depth of peel			
	Superficial	Medium	Deep
Examples	Glycolic acid (AHA), salicylic acid (BHA), LHA, Jessner's solution, TCA (10–30%)	TCA (35%), combinations (Monheit's, Brody's, Coleman's)	Phenol
Indications	Acne, pigmentary disorders, photoaging	Photoaging, superficial atrophic scars	Pigmentary disorders, severe photoaging, scars
Complications	Erythema, transient hyperpigmentation, acneiform eruption	Erythema, desquamation, hyperpigmentation, solar lentigines, herpes	Infection, pigmentation abnormality (hyperpigmentation, hypopigmentation, achromia), scarring, cardiotoxicity, pain, erythema, herpes

Abbreviations: AHA, α-hydroxy acids; BHA, β-hydroxy acids; LHA, lipohydroxy acids; TCA, trichloroacetic acid.

including (1) substance used, (2) concentration, (3) pH, (4) skin type, and (5) skin condition.^{23,24} Chemical skin peeling has reported efficacy in treating wrinkles, pigmentary disorders, scars, actinic keratosis, and acne.²³

All chemical peels provide a means to exfoliate the epidermal layer of the skin, but peels are further stratified based upon depth of destruction. Superficial peels exfoliate the epidermis without destroying the basal layer; medium peels penetrate through the epidermis to the papillary dermis, and deep peels reach the midreticular dermis. Superficial peels may be sub-classified into very superficial (exfoliative) and superficial (epidermal).²³ The depth of the peel positively correlates with the healing time, rate and severity of side effects, and the results.²⁴

A firm grasp of the histopathology of skin lesions is a prerequisite to selecting the proper skin peel, as the depth of the peel should be modified to mirror the depth of the lesion. The initial inspection includes an evaluation of the patient's skin type, thickness, and oiliness. Expectations should be appropriately addressed and the patient counseled that "the deeper the peel, the more inconvenience, the more significant the results."²⁴

The general treatment sequence follows a common theme including a priming phase followed by pretreatment, treatment, and postpeeling phases. Priming entails daily tretinoin therapy for 1 month to facilitate homogenous penetration of the peeling agent, as well as daily sunscreen use to stave postinflammatory hyperpigmentation. Prior to treatment, it is imperative to thoroughly clean the skin of fats, oils, and other debris to further facilitate homogenous peel absorption. Skin hydration with moisturizers and photoprotection with sunscreen is important after treatment.²³

Indications for superficial peels include photoaging (roughness, yellow stains, fine lines, keratoses, and solar lentigines), pigmentary disorders (melasma, post-inflammatory), and acne.^{23,25} Wrinkles or deep pigmentation are not amendable to this therapy.²⁴ Mechanistically, superficial peels decrease keratinocyte cohesiveness to promote desquamation. Additionally, they increase activity of epidermal enzymes, leading to epidermolysis and exfoliation.²³ Multiple applications are frequently necessary to induce clinically significant changes. Classes of superficial peels include α -hydroxy acids (AHAs), β -hydroxy acids (BHAs), β -lipohydroxy acids (LHAs), and tretinoin. Glycolic acid, an α -hydroxy acid, is the most commonly used superficial peel.²⁴ A recent development, β -lipohydroxy acids are salicylate derivatives that are unique in that they possess antibacterial, antifungal, and anti-inflammatory properties in addition to their exfoliative ability.²⁵ Given this anti-inflammatory effect, β -lipohydroxy acid peels are preferably utilized in patients with a predisposition to develop postinflammatory hyperpigmentation.²⁴ Other examples of superficial peels includes Jessner's solution (resorcinol, lactic acid, and salicylic acid in ethanol), trichloroacetic acid (TCA) 10% to 15%, and tretinoin.²⁴

Medium depth skin peels are efficacious in treating fine lines and wrinkles, pigmentary disorders, and superficial atrophic scars. However, they are contraindicated for melasma at they may induce post-inflammatory hyperpig-

mentation, thereby worsening the initial condition.²³ Trichloroacetic acid, specifically 35% TCA, is used as a medium-depth peel.²⁴ Medium-depth peels cause coagulation of membrane proteins and necrosis of the epidermis and dermis, thereby stimulating collagen synthesis and keratinocyte regeneration.²³ Application may cause a burning sensation; as such a combination of an oral sedative (i.e., lorazepam) plus a mild analgesic (i.e., tramadol) is often used for patient comfort. In addition, TCA can be combined with other solutions to modify its efficacy and depth of penetration. However, increasing the concentration beyond 35% is not recommended, as it is associated with increased scarring. Examples of combination medium-depth peels include Monet's combination (Jessner's solution with 35% TCA), Brody's combination (solid carbon dioxide plus 35% TCA), and Coleman's combination (70% glycolic acid and 35% TCA).²⁴

The main clinical indications for deep chemical peels include severe photoaging, pigmentary disorders, and scars.²³ Deep peels most effectively induce collagen formation due to their deep penetration to the mid-reticular dermis, thereby restoring the dermal architecture to a more native state.^{23,24} Croton oil and phenols, mixed in various combinations, are the active ingredients of deep peels. Male skin is not amendable to deep peel therapy owing to its thickness.²⁴ Treatment with phenols is very painful and requires general anesthesia or deep sedation. In addition, risk of heart failure associated with its use limits its clinical utility. Cardiac monitoring is required and, as such, laser resurfacing is generally preferred.²³

Chemical skin peel resurfacing is a relatively safe modality for treating specific cutaneous anomalies, but postoperative edema, erythema, and desquamation should be anticipated for all strengths of peels.²⁶ As mentioned previously, the depth of the peel typically correlates positively with the severity of side effects, which can include pigmentary changes, infections, milia, acneiform eruption, scarring, and delayed healing.²³ Pigmentation disorders fall along a spectrum from hyperpigmentation to hypopigmentation to achromia.²³ Deeper peels are associated with an increased risk of herpes infection and appropriate prophylaxis should be considered. Scarring is a dreaded complication that most frequently occurs on the lower part of the face. Delayed healing and persistent redness may herald scar formation, and topical steroid and antibiotic therapy should be initiated upon diagnosis.²⁴ Generally, superficial peels rarely cause complications, but when present they typically are mild. Medium and deep peels may cause erythema lasting multiple days, desquamation, hyperpigmentation, and solar lentigines. In all cases, photoprotection with sunscreen is recommended to reduce some of these complications.

Other Resurfacing/Noninvasive Rejuvenation Modalities

Beyond traditional lasers, peels, and microdermabrasion, a plethora of resurfacing procedures have been developed. These technologies were designed to deliver sufficient energy to induce dermal remodeling and contraction while

minimizing epidermal injury. Compared with more invasive modalities, these are associated with less “downtime” and fewer adverse events. However, results are generally modest and inconsistent with more significant variation in efficacy from patient to patient.²⁷ This manuscript will briefly review microneedling, ultrasound, radiofrequency, and cryolipolysis therapies. Indications range from rejuvenating photoaged skin to improving the appearance of acne-related scarring.

Skin microneedling therapy, also known as collagen induction therapy or percutaneous collagen induction, is a recent addition to the treatment arsenal. A handheld skin-needling roller studded with fine needles is rolled over the skin in multiple directions. This cutaneous insult stimulates fibroblasts, resulting in the production of new, reoriented collagen bundles and dermal thickening, while grossly maintaining the integrity of the epidermis.^{28,29} Microneedling therapy is an effective modality in managing photoaged skin, stretch marks, and post-acne scarring.^{28–30} In a study of 10 patients, subjective improvement in wrinkles, skin texture, and patient satisfaction was noted after 6 microneedling sessions over the course of three months.²⁸ Another investigation of post-acne atrophic scarring demonstrated subjective improvements in appearance, skin texture, and patient satisfaction.³⁰ Microneedling therapy may cause transient pain, erythema, and edema, but retaining the epidermis reduces risk of many risks and side effects.^{28,30} Multiple treatment sessions are frequently needed to achieve lasting clinical improvements, though the optimal treatment duration has yet to be established.

Automated microneedling is the latest development in skin microneedling therapy. The collagen induction therapy is performed by using a pen-like instrument with handle, disposable needles and guides, which are used to adjust needle length.³¹ The device is placed on the skin and the stamping action that places the needles perpendicular to the skin leads to penetration at required depth (→Fig. 1). As compared with the traditional needling roller, this device is easier to use and has theoretical advantage of having more consistent results due to the precise vertical action on the skin.^{31–33} More importantly, since there is no heat involved as with lasers, there is significantly less downtime with this treatment modality. The transient erythema generally lasts for less than 24 hours. In a single-center, rater-

Fig. 1 (A) Pre- and (B) postautomated microneedling (collagen induction therapy) for facial rejuvenation.

Fig. 2 (A) Pre- and (B) post-Ulthera therapy (Ulthera, Inc.) for facial rejuvenation.

blinded, balanced (1:1), split-face, placebo-controlled, parallel group randomized clinical trial, microneedling therapy showed improvement in the appearance of acne scars over time compared with the control group after 3 treatments, with minimal pain.³⁴

The Ulthera system (Ulthera, Inc.) utilizes ultrasound technology to treat skin laxity associated with photoaging. Ultrasound waves deliver focused energy to the dermal and subcutaneous layers, generating heat and inducing thermal coagulation. The resulting inflammatory cascade catalyzes dermal collagen and elastic fiber synthesis. It is hypothesized that collagen contraction and remodeling is responsible for the skin tightening. Ultrasound serves the dual purpose of generating energy and directly visualizing the target, allowing more precise localization of therapy (→Fig. 2). Ultrasound therapy is fairly benign, but can be associated with transient pain, erythema, edema, and purpura. Motor nerve injury, a potentially serious complication, may rarely occur in areas where the facial nerve courses superficially.²⁷

Radiofrequency (RF) is an alternative nonablative skin resurfacing therapy that works by heating water. The dermis and subdermis are selectively targeted, and RF thermal stimulation enhances dermal collagen remodeling and synthesis.³⁵ Contact cooling protects the epidermis from thermal damage.³⁶ Radiofrequency therapy is efficacious in reducing wrinkles and tightening skin laxity. Radiofrequency can be delivered using monopolar (i.e., Thermage/ThermaCool, Valeant Pharmaceuticals International, Inc.; Exilis, BTL Aesthetics), bipolar (i.e., Aluma; eMatrix, Syneron Medical Ltd.), or unipolar (i.e., Accent, Alma Lasers) devices. Monopolar delivery (i.e., Thermage, Exilis) generally penetrates to deeper structures, as compared with bipolar or unipolar devices. Side effects are minimal and include transient local edema and erythema.³⁵

Cryolipolysis (i.e., Zeltiq CoolSculpting, ZELTIQ Aesthetics, Inc.) is a nonsurgical technique employed for localized fat reduction and body contouring. Though the exact mechanism is not known, it is based upon the idea that lipid-rich tissues are more susceptible to cold injury than water-rich tissues.³⁷ Cooling applicators applied to the skin extract heat from the underlying tissues, and after a single treatment, induce lobular panniculitis and thickening of the interlobular fibrous

septa over the subsequent months. Adipocyte apoptosis and resorption of cellular debris and an increased collagen:adipose tissue ratio result in a subcutaneous fat volume reduction.³⁶

Cryolipolysis is an effective body-contouring technique. Postprocedure patient satisfaction surveys and investigator assessments have all demonstrated appreciable fat reduction. According to a recent review, average volume reduction ranged from 14.67% to 28.5% as measured by calipers and 10.3% to 25.5% as measured by ultrasound.³⁷ The dermis, epidermis, nerve, and adnexal structures are unscathed^{37,38} so the side effects are generally mild. Frequently encountered adverse effects are transient and include local erythema, bruising, swelling, changes in sensation (hypersensitivity, hyposensitivity), and pain.³⁷ A rare complication, paradoxical adipocyte hyperplasia has a reported incidence ranging from 0.025%³⁹ to 0.78%⁴⁰ and seems to occur more frequently in men and patients of Hispanic or Latino descent.³⁹ Cryolipolysis has not been found to affect serum lipid levels or liver function tests. Cryolipolysis should not be performed on individuals with cold-induced conditions (i.e., cryoglobulinemia) or in areas with severe varicose veins, dermatitis, or other cutaneous lesions.³⁷ Cryolipolysis is growing in popularity given benign side effect profile when compared with traditional surgical techniques (i.e., liposuction). However, results are generally modest and patient selection is imperfect, as it is still not known which patients will benefit most and which sites are most responsive to therapy.

It is important to note that the majority of these novel modalities, such as ultrasound therapy, radiofrequency therapy, and cryolipolysis, are heavily operator dependent. The results can vary widely depending on the operator's experience, amount of pressure, and duration and/or frequency of the treatment.

Conclusion

Lasers, microdermabrasion, chemical peels, and the other modalities discussed offer alternatives to patients who are either poor surgical candidates or who prefer less-invasive treatments with less downtime. Indications include photoaging, wrinkles, pigmentary disorders, acne, and scarring, and multiple modalities may be combined to enhance efficacy. These approaches vary in invasiveness, degree of clinical changes, and severity of side-effect profile. Side effects are generally mild, but results are modest and require multiple, prolonged treatment regimens. Thus, patient education and expectation management are crucial. Further investigation is necessary to determine optimal treatment frequency and duration and to refine treatment protocols.

References

- Lengyel BA. Lasers: Generation of Light by Simulated Emission. New York: Wiley; 1962:22–28
- Avram M, Ortiz A. Special issue in dermatology and plastic surgery of Lasers in Surgery and Medicine. *Lasers Surg Med* 2015;47(2): 103–105
- Definition and properties of laser light. Available at: <http://oregonstate.edu/ehs/laser/training/definition-and-properties-laser-light>. Accessed March 16, 2016
- Husain Z, Alster TS. The role of lasers and intense pulsed light technology in dermatology. *Clin Cosmet Investig Dermatol* 2016; 9:29–40
- Anderson RR, Parrish JA. Selective photothermolysis: precise microsurgery by selective absorption of pulsed radiation. *Science* 1983;220(4596):524–527
- Preissig J, Hamilton K, Markus R. Current laser resurfacing technologies: a review that delves beneath the surface. *Semin Plast Surg* 2012;26(3):109–116
- Chwalek J, Goldberg DJ. Ablative skin resurfacing. *Curr Probl Dermatol* 2011;42:40–47
- Cohen BE, Brauer JA, Geronemus RG. Acne scarring: a review of available therapeutic lasers. *Lasers Surg Med* 2016;48(2):95–115
- Alexiades-Armenakas MR, Dover JS, Arndt KA. The spectrum of laser skin resurfacing: nonablative, fractional, and ablative laser resurfacing. *J Am Acad Dermatol* 2008;58(5):719–737, quiz 738–740
- Alster TS, Nanni CA, Williams CM. Comparison of four carbon dioxide resurfacing lasers. A clinical and histopathologic evaluation. *Dermatol Surg* 1999;25(3):153–158, discussion 159
- You HJ, Kim DW, Yoon ES, Park SH. Comparison of four different lasers for acne scars: resurfacing and fractional lasers. *J Plast Reconstr Aesthet Surg* 2016;69(4):e87–e95
- Ciocon DH, Doshi D, Goldberg DJ. Non-ablative lasers. *Curr Probl Dermatol* 2011;42:48–55
- Goldberg DJ. Current trends in intense pulsed light. *J Clin Aesthet Dermatol* 2012;5(6):45–53
- Spencer JM. Microdermabrasion. *Am J Clin Dermatol* 2005;6(2): 89–92
- Freedman BM, Rueda-Pedraza E, Waddell SP. The epidermal and dermal changes associated with microdermabrasion. *Dermatol Surg* 2001;27(12):1031–1033, discussion 1033–1034
- Coimbra M, Rohrich RJ, Chao J, Brown SA. A prospective controlled assessment of microdermabrasion for damaged skin and fine rhytides. *Plast Reconstr Surg* 2004;113(5):1438–1443, discussion 1444
- Karimipour DJ, Karimipour G, Orringer JS. Microdermabrasion: an evidence-based review. *Plast Reconstr Surg* 2010;125(1):372–377
- Spencer JM, Kurtz ES. Approaches to document the efficacy and safety of microdermabrasion procedure. *Dermatol Surg* 2006; 32(11):1353–1357
- Wang SQ, Counters JT, Flor ME, Zelickson BD. Treatment of inflammatory facial acne with the 1,450 nm diode laser alone versus microdermabrasion plus the 1,450 nm laser: a randomized, split-face trial. *Dermatol Surg* 2006;32(2):249–255, discussion 255
- Bhalla M, Thami GP. Microdermabrasion: Reappraisal and brief review of literature. *Dermatol Surg* 2006;32(6):809–814
- Alam M, Omura NE, Dover JS, Arndt KA. Glycolic acid peels compared to microdermabrasion: a right-left controlled trial of efficacy and patient satisfaction. *Dermatol Surg* 2002;28(6): 475–479
- Hussein MR, Ab-Deif EE, Abdel-Motaleb AA, Zedan H, Abdel-Meguid AM. Chemical peeling and microdermabrasion of the skin: comparative immunohistological and ultrastructural studies. *J Dermatol Sci* 2008;52(3):205–209
- Fischer TC, Perosino E, Poli F, Viera MS, Dreno B; Cosmetic Dermatology European Expert Group. Chemical peels in aesthetic dermatology: an update 2009. *J Eur Acad Dermatol Venereol* 2010; 24(3):281–292
- Landau M. Chemical peels. *Clin Dermatol* 2008;26(2):200–208
- Berson DS, Cohen JL, Rendon MI, Roberts WE, Starker I, Wang B. Clinical role and application of superficial chemical peels in today's practice. *J Drugs Dermatol* 2009;8(9):803–811
- Friedman S, Lippitz J. Chemical peels, dermabrasion, and laser therapy. *Dis Mon* 2009;55(4):223–235

- 27 Minkis K, Alam M. Ultrasound skin tightening. *Dermatol Clin* 2014;32(1):71–77
- 28 El-Domyati M, Barakat M, Awad S, Medhat W, El-Fakahany H, Farag H. Multiple microneedling sessions for minimally invasive facial rejuvenation: an objective assessment. *Int J Dermatol* 2015; 54(12):1361–1369
- 29 Schwarz M, Laaff H. A prospective controlled assessment of microneedling with the Dermaroller device. *Plast Reconstr Surg* 2011; 127(6):146e–148e
- 30 El-Domyati M, Barakat M, Awad S, Medhat W, El-Fakahany H, Farag H. Microneedling therapy for atrophic acne scars: an objective evaluation. *J Clin Aesthet Dermatol* 2015;8(7):36–42
- 31 Arora S, Bhandaree Gupta P. Automated microneedling device – a new tool in dermatologist's kit. *J Pak Assoc Dermatol* 2012;22:354–357
- 32 Kim JH, Park HY, Jung M, Choi EH. Automicroneedle therapy system combined with topical tretinoin shows better regenerative effects compared with each individual treatment. *Clin Exp Dermatol* 2013;38(1):57–65
- 33 El-Domyati M, Medhat W. Minimally invasive facial rejuvenation: current concepts and future expectations. *Expert Rev Dermatol* 2013;8:565–580
- 34 Alam M, Han S, Pongprutthipan M, et al. Efficacy of a needling device for the treatment of acne scars: a randomized clinical trial. *JAMA Dermatol* 2014;150(8):844–849
- 35 Beasley KL, Weiss RA. Radiofrequency in cosmetic dermatology. *Dermatol Clin* 2014;32(1):79–90
- 36 Stewart N, Lim AC, Lowe PM, Goodman G. Lasers and laser-like devices: part one. *Australas J Dermatol* 2013;54(3):173–183
- 37 Ingargiola MJ, Motakef S, Chung MT, Vasconez HC, Sasaki GH. Cryolipolysis for fat reduction and body contouring: safety and efficacy of current treatment paradigms. *Plast Reconstr Surg* 2015; 135(6):1581–1590
- 38 Zelickson B, Egbert BM, Preciado J, et al. Cryolipolysis for noninvasive fat cell destruction: initial results from a pig model. *Dermatol Surg* 2009;35(10):1462–1470
- 39 Sasaki GH. Reply: Cryolipolysis for fat reduction and body contouring: safety and efficacy of current treatment paradigms. *Plast Reconstr Surg* 2016;137(3):640e–641e
- 40 Kelly E, Rodriguez-Feliz J, Kelly ME. Paradoxical adipose hyperplasia after cryolipolysis: a report on incidence and common factors identified in 510 patients. *Plast Reconstr Surg* 2016;137(3): 639e–640e