Emerging Technologies in Aesthetic Medicine

Bobby Y. Reddy, MS[a], Basil M. Hantash, MD, PhD[b,*]

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The advent of novel technologies for aesthetic indications has transformed the delivery of skin care in clinical dermatology. The harmful effects of UV irradiation have led to the development of a wide array of treatments aimed at reversing photodamage. One rapidly growing area of skin rejuvenation therapies is laser technology. Ablative lasers (CO_2 and erbium:YAG) have demonstrated unparalleled effectiveness in their ability to treat sun-induced skin damage. Hence, these devices remain the gold standard for skin rejuvenation. However, ablative lasers are associated with significant side effects including delayed erythema and edema, pigmentation abnormalities, significant scarring and increased risk of infection.[1–4] Furthermore, their use also requires a lengthened downtime or period of time after the procedure that patients cannot perform routine activities.[5] These troublesome complications have limited the use of ablative laser devices in clinical practice. Since then, nonablative and fractional lasers have become popular therapeutic options without the side effects associated with ablative procedures. More recently, in light of the efficacy observed with ablative lasers and the success of fractional devices, ablative fractional systems have been introduced, merging the two modalities to deliver exceptional results.[6] This article discusses novel research and emerging technologies in skin rejuvenation. In addition, recent technological interventions for acne vulgaris, lipolysis, and cellulite are also addressed.

AN OVERVIEW OF LASERS AND SKIN REJUVENATION

Rhytides (wrinkles) and skin laxity constitute the primary aesthetically undesired effects of photodamage. All laser and light-based therapies aim to reduce wrinkles without compromising the integrity of the deeper tissue layers. Ablative devices completely eliminate the epidermis and the upper layers of the dermis, inducing the formation of a wound.[6] This lesion subsequently reconstitutes an epithelium in approximately 7 to 14 days.[6,7] In addition to the generation of a wound, ablative therapies also have an important effect on collagen coagulation through the delivery of thermal energy to the surrounding connective tissue.[6] Nonablative lasers heat the deep dermal layers while simultaneously cooling the epidermis.[8] This process achieves the desired effect of dermal regeneration without damaging the epidermal barrier. Although greatly diminishing the adverse effects associated with ablative therapies, a significant loss in clinical efficacy is encountered using nonablative systems.[9] These challenges have led to the emergence of fractional lasers. Fractional devices produce distinct lesions of thermal damage surrounded by larger zones of undisturbed normal skin.[10] The combination of lesions and adjacent viable tissue allows for complete reepithelization within 24 to 48 hours and creates an annular coagulation of collagen, which serves to tighten skin.[11] Fractional lasers are also associated with minimal posttreatment

[a] Department of Dermatology, New Jersey Medical School, Newark, NJ, USA
[b] Department of Surgery, Division of Plastic Surgery, Stanford University School of Medicine, 257 Campus Drive, Stanford, CA 94305-5148, USA
* Corresponding author.
E-mail address: basil@elixirinstitute.org (B.M. Hantash).

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care and lack the significant side effects associated with ablative therapies.

Through different mechanisms, all laser therapies utilize thermal energy to reform and homogenize connective tissue. Initially, there is a localized coagulation of collagen fibers for 14 days post-treatment, and this process is followed by new connective tissue synthesis from the thermally altered matrix.[6,7] Histologically, fibroblasts may be observed migrating to the affected regions and initiating new collagen formation.[12] The entire process is mediated through the activation of various cytokines and molecular pathways, and culminates in increased elasticity and improved aesthetic appearance of skin.[13]

EMERGING THERAPIES

Fractional Lasers

The emergence of fractional resurfacing or fractional photothermolysis (FP) has significantly advanced laser skin therapy. The first fractional device approved for clinical use was the non-ablative laser Fraxel (Reliant Technologies, Mountain View, California).[10] This 1550 nm erbium-doped fiber laser was designed to generate microscopic treatment zones (MTZ), areas of thermal necrosis surrounded by viable tissue.[7] This mixture, resulting from interlesional sparing, allows for rapid reepithelialization of thermally damaged zones.[14] Fraxel maintains an undamaged stratum corneum, which greatly reduces the risk of developing a bacterial infection resulting from treatment.[10] Furthermore, the preserved epidermal barrier serves to function in exfoliating underlying coagulated tissue, referred to as microepidermal necrotic debris (MEND).[10] Studies have demonstrated that MEND contains melanin and elastin.[10] The transepidermal elimination of melanin may explain the observed efficacy of FP in the treatment of melasma.[15] Complete regeneration using this device takes approximately 3 months, and it involves the recruitment of various cytokines and mediators, such as heat shock proteins and transforming growth factor-β (TGF-β).[10] An important technical feature of the Fraxel laser is the Intelligent Optical Tracking system (IOTS), which serves to remove the necessity of stationary treatment. The IOTS allows for the production of constant density MTZ while screening the physician's hand speed, preventing nonuniform treatment distributions.[10] Prior to the emergence of IOTS and FP, treatment for skin rejuvenation was restricted to the face because of the risks of scarring and hyperpigmentation associated with treating other areas. The Fraxel laser coagulates approximately 20% of the target zone, hence the risk of collateral thermal damage is drastically diminished.[10] This advantage has allowed for efficacious treatment of nonfacial areas with short healing periods.[16] Because of rapid healing and few side effects, this device proved to be a more convenient and safer treatment option than the existing ablative and nonablative lasers. The potential therapeutic benefits of this revolutionary device are only beginning to unravel.

Since then, other fractional laser therapies have emerged, steadily enhancing the options for treatment. The 1540 nm-pulsed device, Lux 1540 Fractional (Palomar Medical Technologies, Burlington, Massachusetts**)**, has been approved by the US Food and Drug Administration for soft-tissue coagulation.[17,18] This device includes a convenient handpiece connected to a pulsed light and laser system that delivers microbeams of pulsed light capable of penetrating 1mm of skin.[17] A major benefit of this system is the fact that it is completely painless, making it a reliable option for patients who are especially intolerant to pain.[17] Another new fractional system is the Affirm laser (Cynosure Inc., Westford, Massachusetts), which sequentially emits two different laser wavelengths (1320 nm and 1440 nm).[17] This device utilizes a unique microlens array to dispense laser light at two wavelengths through a network of microbeams, allowing for high-intensity penetration of the superficial and deep layers of skin.[17] Unlike the Fraxel laser, this system does not require a tracking dye and is associated with much less pain, as a result of the more superficial microtreatment zones.[19]

Recently, fractional ablative lasers based on CO_2 and heated Er:YAG systems have also been introduced. The 10,600 nm AFR system (Reliant Technologies Inc.) is the prototype fractional ablative CO_2 laser.[20] This novel device generates MTZ with variable depths and widths through manipulation of pulse energy delivery.[21] These areas of tissue ablation are bordered by zones of tissue coagulation, representing denatured collagen.[22] There is an annular ring pattern of coagulation surrounding the microlesions generated with AFR treatment.[20] This annular configuration of thermal coagulation may serve to enhance tissue tightening benefits because of collagen shortening in a three-dimensional mechanism.[21] Treatment with this device also employs transepidermal exfoliation of MEND, as observed with nonablative fractional photothermolysis. Furthermore, immunohistochemical studies of treated skin demonstrated the induction of epidermal heat shock proteins and a significant collagen remodeling/wound healing response lasting 3 months.[21]

Fractional ablative resurfacing may also be performed through Er:YAG lasers. The prototype 2940 nm Er:YAG laser Pixel (Alma Lasers Ltd,