This chapter reviews the use of dermal filling agents in combination with laser resurfacing for the improvement of photodamaged facial skin and atrophic facial scars. Emphasis is placed on proven techniques for both light- and dark-skinned patients. In addition, a comprehensive review of dermal filling agents is included because soft tissue augmentation is often combined with laser treatments.

Pathologic Anatomy

Superficial wrinkles are textural changes that result from intrinsic aging and photoaging. Mimetic wrinkles are lines or furrows caused by deep dermal creases from repetitive muscle movement (combined with dermal elastosis). Folds are defined as overlapping, sagging skin.

Topical exfoliating agents primarily affect the epidermal level and, over time, possibly benefit the dermis. Deeper resurfacing procedures (laser resurfacing, chemical peels, dermabrasion) are designed to improve the skin by “sanding down” adjacent tissue so that rhytides and scars are less apparent. They may also produce collateral improvement of the dermal layer. Nonablative technology with cumulative applications is designed to restore the dermis and bypass the epidermis, thereby avoiding the erythema associated with traditional laser technology.

Injectables or soft tissue filler materials are intended to restore a more youthful facial contour by replacing lost dermal elements or subcutaneous fat. A plethora of filling agents are available and fall into five categories: natural human materials (e.g., AlloDerm, autologous fat), sources derived from animals (e.g., bovine collagen), synthetic materials (e.g., hyaluronic acid products), materials of a chemical nature (e.g., silicone), or combined materials (e.g., inner methylmethacrylate beads covered with a collagen surface). Alternatively, fillers can also be classified as temporary or permanent. Almost all fillers are temporary other than silicone. No ideal filler material yet exists. However, because of patient demand and manufacturer interest, the field of injectable soft tissue fillers is rapidly evolving.

Goals of Treatment

The goals of restoring the youthful appearance of an aging face are as follows:

1. Replace—replacing atrophic dermal or subcutaneous structures
2. Recontour—reshaping facial volume
3. Resurface—resurfacing the skin surface
4. Relax—improving rhytides by relaxing the causative muscle
5. Reposition/redrape/remove—anatomic repositioning and redraping of loose sagging soft tissue

Diagnostic Studies

There are no specific diagnostic studies unless pathologic conditions (e.g., Ehlers-Danlos syndrome) are suspected. A photographic record is valuable.
Laser Skin Resurfacing and Fillers

Figure 1 • A, Periorbital and brow rhytides. B, Appearance 6 months after CO₂ laser resurfacing.

Cutaneous Laser Resurfacing

Since the mid-1990s, the effectiveness of high-energy, pulsed, and scanned carbon dioxide (CO₂) and erbium:yttrium-aluminum-garnet (Er:YAG) lasers has been established for the treatment of photoinduced facial rhytides, dyschromia, and atrophic scars.

With a wavelength of 10,600 nm, the CO₂ laser uses tissue water as its targeted chromophore and vaporizes 20 to 30 μm of tissue per pulse, thus effectively removing the entire epidermis in a single laser pass using typical treatment parameters. This action produces a limited spread of coagulative necrosis (50 to 150 μm wide) that induces new collagen formation and persistent dermal remodeling—the process responsible for the majority of the long-term benefits of treatment (Fig. 1). Although the CO₂ laser typically produces at least 50% improvement in rhytid severity or scar depth after treatment, it is associated with the highest post-treatment morbidity and risk of adverse sequelae.

The erbium laser, with a wavelength of 2940 nm, has a much higher absorption coefficient than does the CO₂ laser, and its energy is 12 to 18 times more efficiently absorbed by water-containing tissues. As a result, most of this laser’s energy is absorbed by water within the superficial epidermis, causing the thermal energy to be ejected within the desiccated tissue during laser irradiation. Each pass of the erbium laser penetrates to a depth of 2 to 5 μm per pulse and produces a zone of thermal necrosis ranging another 20 to 50 μm after a typical multi-pass procedure. The erbium laser is a precise ablative tool that produces little residual thermal damage and therefore minimal long-term neocollagenesis. The major disadvantage of the erbium laser system is the lack of intraoperative hemostasis because of inadequate vessel coagulation.

Newer long-pulsed erbium laser systems have been developed in an attempt to reduce these shortcomings, most notably effecting collagen shrinkage and improved vessel coagulation. By generating pulse widths up to 500 μm, larger zones of thermal necrosis are created with resultant collagen contraction and remodeling. Although the long-pulsed erbium laser approaches the CO₂ laser in terms of its effect on dermal tissue, it is not associated with as long a postoperative recovery course nor as high a risk for postoperative complications.

The relatively new “nonablative” laser systems have gained in popularity because an increasing number of patients are willing to accept more modest improvement, particularly when only limited or no recovery time is available. Infrared-range laser systems, including the 1320-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser, the 1450-nm diode laser, and the 1540-nm erbium:glass laser, are most commonly used for nonablative skin resurfacing. Tissue water is also the targeted chromophore, and heat energy is largely deposited in the upper papillary dermis, where the bulk of solar elastosis is located. Dynamic cryogen spray devices or contact cooling handpieces are used for epidermal preservation. Multiple nonablative treatment sessions are typically recommended at monthly intervals, and the final clinical results may not be apparent for 4 to 6 months after the final treatment session. Clinical results are not as favorable as those observed after ablative laser resurfacing, but a 20% to 50% improvement can be expected (Fig. 2).

Technique

No consensus exists regarding whether pretreatment with topical retinoids, α-hydroxy acids, or hydroquinone-containing compounds enhances
post-laser resurfacing results. Antiviral prophylaxis for herpes simplex virus exposure or reactivation is required when treating the perioral area in all patients. In addition, perioperative antibiotic prophylaxis is also recommended for all patients.

**CO₂ Laser**

When using the CO₂ laser, either an entire aesthetic unit or the full face should be treated to avoid obvious lines of demarcation between treated and untreated skin. A treatment fluence of 300 mJ is most commonly used for the initial pass in patients with lighter skin types and 200 to 250 mJ in those with darker skin. Adjacent scans are directed in a nonoverlapping manner to avoid excessive heat deposition and spread of thermal damage to unintended tissue structures. Because the depth of ablation and degree of residual thermal damage are directly correlated with the number of laser passes performed, stacking of pulses or scans must be strictly avoided to decrease the risk of hypertrophic scar formation or hyperpigmented streaking in darker-skinned individuals. Successive passes (two to three on average) should be performed only after the desiccated tissue has been completely removed from the surgical field. Excessive deposition of heat occurs because desiccated tissue acts as a heat sink for progressive thermal damage. The direction of laser passes should also be alternated to avoid striped patterns on the skin. For atrophic facial scars, the 3-mm handpiece can be used to sculpt scar edges for maximal flattening. Only a single pass of the laser at reduced fluence should be delivered along the mandibular border because of the tendency for hypertrophic scar formation in this area. An increasing number of surgeons are now performing single-pass CO₂ laser resurfacing to avoid many of the aforementioned complications. In this technique, a single laser pass is delivered with the scanner, followed by freehand use of the 3-mm spot size handpiece to “fill in” any untreated areas. The partially desiccated tissue is left intact after the procedure to serve as a biologic dressing; the tissue typically sloughs off after 3 to 4 days. The single-pass technique is preferred for patients with darker skin tones to avoid postinflammatory hyperpigmentation. Additional laser passes can be applied to focal areas (e.g., cheek scars, upper lip rhytides) as necessary to effect more tissue tightening.

**Erbium:YAG Lasers**

Short- and long-pulsed Er:YAG lasers can also be used to treat photodamaged facial skin and atrophic scars. With the short-pulsed systems, the main goal is to maintain a uniform cutaneous surface and ablative depth. Because this system has high affinity for water-containing structures, the surgical field must be dry before treatment. Any moisture on the field absorbs the laser energy and renders the treatment less effective. The entire epidermis can be removed after two to three passes at 5 to 10 J/cm², whereas focal areas with either more photodamage or deeper scars can receive additional passes. Fewer passes should be applied at the treatment periphery to ensure natural blending between treated and untreated skin. In general, it is more difficult to
POSTOPERATIVE MANAGEMENT. Either an open or closed wound care technique can be used postoperatively. The open technique involves the application of topical barrier ointments such as Aquaphor, Catrix 10, or plain petrolatum for the first 3 to 5 postoperative days, whereas a transparent, semioclusive dressing such as Vigilon or Silon-TSR is left intact on the laser-treated skin in the closed technique. The dressings must be changed at least every 24 hours to avoid bacterial colonization and permit proper wound visualization. Some physicians prescribe the closed technique for the first few days in an attempt to reduce patient discomfort, followed by an open technique for the remainder of the healing period.

Postoperative side effects and complications are similar after either erbium or CO₂ laser skin resurfacing. Transient erythema, edema, and serous discharge are universal findings. The degree of postoperative erythema is directly correlated with the level of ablation and the amount of residual thermal damage produced. Erythema after multipass CO₂ laser skin resurfacing typically persists for 3 to 6 months, whereas it usually resolves within only 1 month after erbium laser treatment. Milia formation, exacerbation of acne, contact allergies, superficial bacterial infections, and reactivation of herpes simplex are other potential postoperative complications. Pigmentary alterations, including hyperpigmentation and delayed-onset hypopigmentation, may also develop. Hyperpigmentation is most common in patients with dark or olive skin tones and can be effectively treated with topical bleaching or peeling agents (e.g., hydroquinone, glycolic acid). Severe complications, including hypertrophic scar formation, ectropion, and systemic infection, are rare.

Soft Tissue Augmentation

Many dermal filling agents are available for soft tissue augmentation. Most of these substances are best used in the lower part of the face and can be combined with other rejuvenative procedures such as cutaneous laser resurfacing or botulinum toxin injection. Requirements for the ideal soft tissue filler are outlined in Table 1.

**Injectable Bovine Collagen**

Bovine collagen implants are the most popular dermal filling agents used. The implants consist of purified, reconstituted, fibrillar bovine type I and type III collagen. Because bovine collagen is xenogeneic, double skin testing is mandatory 1 month before implantation to assess the risk for a hypersensitivity reaction.

Zyderm I is best injected as superficially as possible for treatment of the fine lines around the eyes and mouth with approximately 200% overcorrection. Zyderm II is best suited for scars and glabellar frown lines and should also be placed in the superficial dermis. Zyplast is reserved for deeper lines (e.g., nasolabial folds) and larger defects (e.g., surgical/traumatic scars) and may be used as a base for more superficially placed Zyderm I or II. Zyplast should be placed in the middermis without visual overcorrection (it should be palpable but not seen).

The major disadvantage of collagen implantation is its relatively short duration (3 to 6 months), thereby requiring frequent reimplantation. Side effects are rare but include allergic reactions (3% to 5%) that are manifest clinically as erythema and induration. Systemic steroids may be used to treat this condition, but it may recur after discontinuation of the steroids. Two other serious, albeit rare, complications of collagen implantation include vessel occlusion and abscess formation. The risk for vessel occlusion is highest with the use of Zyplast in the glabellar region. The area immediately becomes painful and dusky colored, whereupon the injection should be discontinued and ice applied. Abscesses may form at any time (even several months) after implantation, and treatment should include the use of intralesional or systemic steroids, as well as incision and drainage. These patients tend to have high levels of anti-bovine collagen antibodies and should not receive further treatment with bovine fillers.

**Autologous Filling Agents**

ISOLAGEN. Isolagen is an autologous collagen process whereby dermal fibroblasts and type I collagen are obtained from human skin punch biopsy samples and expanded in tissue culture over a 6-week period. A series of injections (1 mL) are delivered to the desired sites at biweekly intervals. The
process should be theoretically associated with a longer duration of correction because increased local production of collagen and decreased degradation by collagenase would be expected.

The thin Isolagen solution is best used for the treatment of fine lines and shallow atrophic scars and is administered through a 30-gauge needle into the upper dermis with 200% to 300% overcorrection. Two to four injection series are necessary to effect improvement of mild to moderate rhytides and scars, whereas five or more sessions are needed for deeper defects. Some studies have shown correction to last as long as 6 months, with the nasolabial folds responding best to treatment. However, other studies have documented its disadvantages, including its subtle treatment effect and greater expense. Because of its low viscosity, most patients find the degree of correction obtained with Isolagen to be less than that obtained with bovine collagen.

**AUTOLOGEN.** Autologen is another autologous injectable collagen that is harvested directly from the dermis of the recipient patient. Excess skin that is excised during routine surgery is processed so that intact collagen fibers are extracted. Tissue processing takes approximately 3 weeks, and the final product can be stored for up to 6 months.

Autologen is injected into the middermis, and nerve blocks or local infiltration with lidocaine is often required before treatment. Serial injections are made with 20% to 30% overcorrection; most patients undergo three treatment sessions at biweekly intervals. Advantages of Autologen for soft tissue augmentation include a relatively long duration and negligible risk of hypersensitivity. The main disadvantage is the large amount of donor skin required for tissue processing.

**Lipotransfer and Lipocytic Dermal Augmentation**

Lipotransfer is best suited for correction of larger-volume defects in the subcutis. Lipocytic dermal augmentation is a refinement of the lipotransfer technique that enables the surgeon to inject processed fat into the dermis for correction. With this method, fat is injected intradermally via 23- or 25-gauge needles with slight overcorrection. Dermal thickness is increased over time because of volume expansion and an inflammatory response. Lipotransfer can be used to augment the subcutis in concert with a lipocytic dermal augmentation procedure to fill dermal defects and rhytides. Transferred fat typically lasts 3 to 6 months, although tissue longevity can be enhanced if treatment is repeated 3 to 4 weeks after the initial session.

**Allogeneic Human Collagen**

**DERMALOGEN.** Dermalogen is a neutral pH buffer solution of human tissue collagen matrix processed from the dermal layer of deceased donor skin specimens. This Food and Drug Administration (FDA)-approved tissue product consists of intact collagen fibrils, elastin, and glycosaminoglycans and is procured from accredited tissue skin banks. Dermalogen is processed with two viral and prion inactivation steps to ensure safety.

Dermalogen is best used for amelioration of prominent nasolabial folds, glabellar frown lines, perioral rhytides, and atrophic scars. Because of its high viscosity, Dermalogen should not be used for fine perioral or periorbital rhytides. Dermalogen should be injected into the mid to deep dermis by a series of injections with a 30-gauge needle at a 30- to 45-degree angle to the skin surface. One must be careful to avoid placement of the material too superficially to prevent the formation of small, white, beaded elevations that resemble milia. Defects should be overcorrected by 10% to 20%. Most patients require three treatment sessions at biweekly intervals for best results.

Side effects of treatment with Dermalogen include burning and stinging at injection sites, prolonged erythema, and acne-like eruptions. The main disadvantages include concern regarding tissue safety and the significant pain experienced during injection.

**ALLODERM.** AlloDerm is an acellular dermal graft processed from tissue bank–derived human skin. The graft is processed by removal of epidermal and dermal cells, which are antigenic targets of cell-mediated immunity. The dermal tissue that is implanted serves as a matrix for migration and repopulation by the recipient's own fibroblasts and endothelial cells. Allografts are screened for viruses before use. In addition, transplanted tissue is treated with antiviral agents that inactivate human immunodeficiency virus, and the living cells responsible for propagation of viral diseases are extracted from the graft. Thus far, there have been no reported cases of transmission of viral disease as a result of dermal graft implantation.

AlloDerm implantation requires the use of local anesthetics or nerve blocks, or both. The graft is first rehydrated in saline, and a 1- to 2-mm piece is introduced through small incisions in the skin surface, such as the lips, and sutured into place. AlloDerm implants are particularly useful for the treatment of iatrogenic depressions after liposuction.

**Synthetics**

**HYALURONIC ACID.** Derivatives of hyaluronic acid include Hylan B gel and Restylane. Hyaluronic acid is a naturally occurring polysaccharide component of the intercellular matrix that is responsible for hydration and stabilization of the connective tissue–containing cells of the dermis. Hylan B gels are cross-linked hyaluronan polymers with high molecular weight and relatively long duration in
tissue. Side effects of treatment include transient erythema and bruising. There is little risk of allergic reaction with this implant because the natural hyaluronan polymer exhibits no species specificity and does not induce a significant immune reaction.

Restylane has several advantages over other filling agents. It is relatively complication free and delivers a predictable soft tissue result that lasts 4 to 6 months. There is minimal pain with injection and it has a natural feel. It should be injected into the reticular dermis via a threading technique. It is most useful for lip, nasolabial fold, and “marionette” lines.

**ARTECOLL.** Artecoll is an implant made of polymethylmethacrylate beads suspended in 3.5% atelocollagen with lidocaine. The telopeptide ends of the collagen moiety are removed to reduce antigenicity. Artecoll beads range in size from 30 to 40 μm and are implanted via 27-gauge needles after skin testing to document possible hypersensitivity. Artecoll should be placed between the lower dermis and subcutaneous fat without overcorrection by using a fanning motion and injection on both entering and exiting the skin. After implantation, the collagen moiety is phagocytized over a 1- to 3-month period and is replaced by newly synthesized fibroblasts and collagen fibers. Treatments are repeated at 1- and 3-month intervals for complete correction of defects. Side effects include temporary erythema, edema, pruritus, and moderate pain. Allergic reaction to the bovine collagen portion of the implant is another potential complication, and rates of reaction are similar to those of other injectable bovine products.

**POLY-L-LACTIC ACID.** Poly-L-lactic acid (Sculptra, Dermik Laboratories) is the latest addition to the expanding armamentarium of filler materials. It is the same material used in absorbable sutures and is indicated for deeper dermal filling to create more durable and greater volume replacement. It is highly biocompatible and nonallergenic; thus it can be used without skin testing. The material is biodegradable, yet the results achieved after a series of 3 to 5 monthly injections are relatively long-lasting, averaging 2 or more years, presumably because of neocollagenesis. It can be used in combination with more superficial filler materials in a layering technique for patients with both volume loss and superficial rhytides.

Poly-L-lactic acid is supplied as a lyophilized powder in a vial that is stored at room temperature. It is reconstituted with sterile water for injection to a volume of 5 mL and left to rehydrate for 2 hours. The contents of the entire vial are used at each session (in 0.1-mL to 0.2-mL aliquots) for cosmetic correction of nasolabial or mesolabial folds. Greater volumes may be needed to achieve the desired results in persons with more profound defects, such as in individuals with HIV-associated lipoatrophy.

**SUGGESTED READINGS**


