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Facial Plastic Surgery

The Aging Face—
Benefits and Pitfalls of Botox® and Laser Skin Treatments

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The effects of aging on the skin are a result of a combination of many factors. The most obvious manifestations of aging are recognizable in the face. Most adults can instantly estimate a person's age at a glance, based on the quality and certain characteristics of the facial skin and the underlying facial contours. We have a mental image of what a person looks like in the 40s or 50s or beyond, and most of us strive to look "good" for our actual age. Although aging skin is a fact of life, and some of the effects of aging are related to genetic factors beyond our control, many treatments and techniques are available today through facial plastic surgeons and other skin care specialists to help reduce the effects of aging on skin. In particular, there are advances in nonsurgical management of senescent skin that are increasingly effective in combating the signs of aging, such as injectable agents like Botox® (botulinum toxin A) and laser skin treatments. Proper matching of techniques with specific age-related changes is important for successful management.

Effects of Aging on Skin

The appearance of the aging face is a result of many factors, both genetic and environmental. There are intrinsic factors of cutaneous aging that are characterized by a loss of skin elasticity and volume. There is a loss of the rete pegs in the cutaneous dermal-epidermal junction and atrophy of the dermis, resulting in thinning, laxity, and fine wrinkling of the skin. In addition, there is a loss of the underlying adipose tissue in the face, known as lipoatrophy, resulting in a thinner, increasingly gaunt appearance to the face. The roundness of the cheeks and lips associated with youth gives way to thinning of the lips, hollowing of the cheeks and orbits, and creping of the eyelid skin.

Photoaging of the skin causes the most pronounced negative impact on the senescent face. Overexposure to ultraviolet light from the sun is the cause of the majority of the damage associated with the aging face. Glogau classified photoaged skin into four subtypes based on the clinical manifestations of photoaging, including changes in skin color, wrinkling, and texture.¹ Photodamage is the cause for "age spots," dyschromias, lentiges, telangiectasias, and the progressive sallow yellow color and overall splotchy pigmentation of the senile facial skin. Poikiloderma of Civatte—the "redneck" appearance noted on photoaged cervical and cheek skin—is primarily the result of solar damage. With increasing sun exposure and photodamage, surface growths and scaling such as actinic keratoses, seborrheic keratoses, and even skin

cancers appear on the face, giving the skin surface a rough, uneven texture. Premature senescent changes of the skin are also associated with other environmental factors, most notably smoking and poor nutritional status.

Expression lines or laugh lines are dynamic, hyperkinetic rhytids of the face resulting from repetitive facial muscle movements. Because the muscles of the face insert into the deep layers of skin, movements of these muscles cause crinkling of the overlying skin. Over the years, this repetitive crinkling of the skin causes permanent creases or deep rhytids on the face. These are most noticeable in the area around the large muscles of the eyes, forehead, and mouth, where smiling, laughing, and frowning cause permanent changes in the dermis. The vertical frown lines in the glabella region between the eyebrows result from contraction of the corrugator muscles, while the horizontal rhytids at the root of the nose are due to contraction of the procerus muscle. Crow's feet lines form with contraction of the orbicularis oculi, and the large horizontal rhytids across the forehead result from brow elevation by the frontalis muscle. Vertical lines form around the lips, especially in smokers, from repetitive puckering and sucking.

Last, but not least, gravity and its constant downward pull on the soft tissues of the face is a factor in aging, and the facial structures are not immune to its effect. With increasing age, as the skin intrinsically becomes progressively thinner and less elastic, gravity acts on the facial soft tissues. The brow lines droop, the lower eyelids sag, jowls form along the jaw line, and the malar eminence (or

prominence of the cheek) crowds downward toward the nasolabial fold. In addition, the nasal tip begins to point downward and the earlobes elongate, giving adage to the old children's song, "Do your ears hang low."

Treatment Options

A variety of treatment options are available to help diminish the signs of aging. Certainly, many surgical options are available to improve one's appearance, such as rhytidectomy, blepharoplasty, and brow lift, and these procedures are the primary armament in the correction of the gravitational effects of aging. The focus of this discussion, however, is on minimally invasive procedural treatments for the face to improve age-related skin changes. These include injectable medications and materials that can reduce the signs of aging, such as botulinum toxin A, as well as laser resurfacing treatments used to improve skin quality and contour.

It is important to note that the prevention of further skin damage by avoiding overexposure to the sun and using sun screen regularly should be the first-line treatment for all patients. Smoking cessation and maintaining good nutrition and hydration will also help reduce age-related skin changes. In addition, a multitude of medical skin treatments and cosmetic products are available that can be modestly beneficial in reducing fine rhytids and pigment irregularities with long-term use, such as topical applications of antioxidant products, retinoic acids, glycolic acids, or growth factor serum.

Botox®

A main focus of this paper is a discussion of the use of botulinum toxin in management of the aging face. Botox is the trade name for purified botulinum toxin A made by the Allergan corporation. Although botulinum toxin is considered one of the most lethal known poisons, in small therapeutic doses it is extremely safe and effective in treating hyperkinetic expression lines. It has been used safely in clinical applications since the 1970s to treat functional disorders like strabismus, blepharospasm, and spasmodic dysphonia. In 2002, Botox was approved by the FDA for cosmetic purposes for the treatment of the vertical and transverse frown lines of the glabella between the eyebrows. These are caused by contraction of the corrugator and procerus muscles, respectively. Since its FDA approval for cosmetic use, many new uses for Botox have been explored and touted by physicians.

Botulinum toxin causes a temporary weakness of the targeted facial muscle, which can last for three to five months. It is a neuromuscular blocking agent that works locally at the neuromuscular junction to block the release of acetylcholine, a nerve transmitter, at the presynaptic membrane of the nerve terminals.² Because acetylcholine is blocked, the force of muscular contraction is reduced. In the region of the injection, it effectively causes a reversible denervation of the injected muscle tissue. This results in muscle atrophy in the region of the injection, with reduction of the muscle fiber diameter and weakness. Because the neurotoxic effects are localized, only parts of the mus-

cle are affected, and because only small amounts of toxin are used clinically, the muscle is not completely paralyzed (contrary to some representations in the media). With weaker and less repetitive movement of the muscle, there is less crinkling of the overlying skin, and the expression lines smooth out or are even eliminated.

Botulinum toxin A is most frequently used in the upper third of the face to treat the dynamic expression lines of the glabella, forehead, and periorbital region. Excellent results have been reported in reducing the hyperkinetic rhytids in these areas.³ The effects of Botox are noted approximately 72 hours to one week after injection. Many doctors have used the toxin effectively to treat other hyperkinetic lines, most notably nasal scrunch or "bunny" lines, vertical lip rhytids or "smoker's lines," and the marionette lines along the melolabial folds. Botulinum toxin has also been found to be useful in treating the muscle hypertrophy seen in platysmal banding of the neck.

Although Botox has an excellent safety record, it is important to weigh the desired clinical effect with injection at any of these sites with the potential for overtreatment and complications. Botulinum toxin is produced by the bacteria *Clostridium botulinum*, which is the cause of botulism. Botulism is most commonly linked to food contamination, and can result in a generalized flaccid paralysis leading to death if respiratory support is not provided. Fortunately, the chemodenervation that occurs after botulinum toxin injection is temporary. There have been no long-term complications reported in the use of Botox

in the face, and there have been no life-threatening allergic reactions reported.⁴

The recent cases of injection-induced botulism reported in Florida, in 2004, were reportedly caused by injections with exceedingly large doses of an unlicensed botulinum toxin product labeled for animal research. The average patient injection for aesthetic purposes generally ranges between 25 and 50 units. Each vial of Botox contains only 100 units of purified toxin, while the estimated minimum lethal dose of neurotoxin would be equivalent to approximately 3,000 units.

Minor, regional complications of Botox injections may occur following treatment. Ecchymosis and pain at the site of the injection are the most common reported complications, and may be dependent upon the injection technique itself. Headaches, dry mouth, nausea, and flu-like symptoms can arise after Botox injections, as well as localized skin dryness due to decreased sweat gland activity.⁵ Allergic reactions to Botox are extremely rare. Botulinum toxin injections are contraindicated in patients with a skin infection in the area of the proposed injection, and should not be used in patients with peripheral neuropathic or neuromuscular disorders such as amyotrophic lateral sclerosis or myasthenia gravis.

The majority of the remaining potential complications can be classified as localized functional or esthetic deficits secondary to diffusion or improper placement of the toxin during injection. Blepharoptosis is the most fre-

quently reported deficit resulting as an unintentional side effect from periorbital toxin injections, with an estimated incidence of 1 to 3 percent.⁶ Injection outside the orbital rim is recommended to prevent inadvertent toxin effects on the levator palpebrae superioris muscle. Digital pressure on the orbital rim as the injection is performed can also reduce accidental diffusion of toxin into the orbital zone. Botulinum toxin-induced blepharoptosis is temporary but, if necessary, can be managed with a topical alpha adrenergic agonist. Aproclonidine 0.5 percent eye drops can be applied to help stimulate Mueller's muscle to raise the lid 1 mm to 2 mm.

Other areas that may develop unintentional functional deficits include brow ptosis following injection of the frontalis muscle. Because this is the only brow elevator, unopposed action by the brow depressor muscles (corrugator, procerus, and orbicularis oculi) can cause an apparent droop in the eyebrows. Cautious, conservative injection of the frontalis, along with simultaneous injection of the corrugator, can help prevent this effect. The use of botulinum toxin in the perioral area can be complicated by oral incompetence or asymmetries. Keeping melolabial injections 1 cm away from the oral commissure and injecting superficially along the vermilion will smooth out vertical lip rhytids, while reducing the risk of incompetence. Additionally, injection too deeply into the platysmal bands can result in dysphagia or alterations in the voice by affecting the strap and cricothyroid muscles.

Laser Facial Rejuvenation

Although botulinum toxin injections are aimed primarily at dynamic, hyperfunctional rhytids of the upper third of the face, laser treatments to the skin are aimed at correcting the effects of photoaging. Differentiation between static and dynamic wrinkles and the degree of photoaging should be ascertained before attempting laser resurfacing. Rhytids secondary to facial muscle contraction are more impervious to laser resurfacing than nondynamic wrinkles. Improvement in nondynamic wrinkles, skin elasticity, dyschromias, and skin texture irregularities are the expected benefits of laser resurfacing. Laser treatment rejuvenation modalities can be classified as either ablative or nonablative.

Ablative Modalities

The goal of ablative skin resurfacing is to remove the photodamaged epidermis and replace it with a new, undamaged epidermal layer, while enhancing and tightening the dermis through increased collagen and elastin formation. Ablative skin resurfacing techniques denude the epidermis and papillary dermis through selective photothermolysis and controlled tissue vaporization. Re-epithelialization occurs within 7 to 14 days due to the abundance of skin appendages (sweat glands and hair follicles) in the face that provide a source for epidermal cells that migrate upward to form new epithelium. The new skin is fresher, younger looking, smoother, and with fewer pigmentary irregularities. The most commonly used

ablative resurfacing lasers include the CO₂ and erbium:yttrium-aluminum-garnet (Er:YAG) lasers.

CO₂ Laser. The pulsed CO₂ laser emits a 10,600-nm wavelength of infrared light, which targets intra- and extracellular water in the skin tissue. Because skin is 70 percent water by volume, the laser can effectively and selectively vaporize the skin tissue. Histologic evaluation after laser resurfacing with the CO₂ laser reveals it can ablate approximately 50µm to 150µm of tissue per pass, so that two or sometimes three passes are sufficient for removing the epidermis and papillary dermis.⁷ Advances in laser technology have allowed delivery of the CO₂ laser pulse at short pulse durations of less than 1 millisecond. Because this pulse duration is shorter than the thermal relaxation time of skin, the pulsed CO₂ laser leaves a relatively thin zone of nonspecific thermal damage in the residual dermis, when compared to a nonpulsed CO₂ laser.

There are associated thermal effects of this ablation that are desirable—that lead to collagen shrinkage, wound contraction, and subsequent skin tightening. There is also photothermal coagulation at the wound base, so there is little bleeding or wound seepage in the immediate post-treatment period. Although the degree of thermal injury caused by the CO₂ laser plays a significant role in the extent of postlaser collagen remodeling, this thermal damage can extend up to 100 µm, which may lead to complications such as prolonged erythema, hyper- or hypopigmentation, or even scarring.⁸ Other potential complications of laser resurfacing include wound infection, milia formation, contact dermatitis, and delayed healing.

Wound healing after ablation proceeds with re-epithelialization and new collagen and elastin fiber formation in the dermis. The end result reveals significant improvement in skin quality, with smoother, firmer, and tighter skin. However, postprocedure erythema may last for several weeks to months. Although the reduction in photodamage and wrinkling of the skin following CO₂ laser treatments is excellent, the enthusiasm for the procedure is tempered by both the long healing time and the degree of anesthesia often required for patient comfort during the procedure.

Er:YAG Laser. The erbium laser has a wavelength of 2,940 nm, which has ten times greater water absorption than the CO₂ laser.⁹ Consequently, it ablates less tissue per pass (20 μm to 40 μm), and has a narrower zone of thermal necrosis (5 to 10 μm per pass). Almost all of the erbium laser energy is converted to water vaporization, leaving less tissue debris and thermal damage. Because it produces less thermal injury than the CO₂ laser, faster healing time can result, with less risk of complications. Alternatively, because it results in less thermal injury, it also produces less collagen remodeling and therefore less significant skin-tightening effect. It is not as effective as the CO₂ laser as a single modality for correcting moderate facial rhytids. However, when used in combination therapy along with the CO₂ laser, it can be a very effective tool in treatment of the photoaged skin.¹⁰ By combining the two lasers, tissue ablation is maximized while detrimental thermal injury effects are minimized.

Nonablative Laser Rejuvenation

Nonablative laser rejuvenation avoids some of the potential risks of ablative procedures, by inducing a dermal inflammatory healing response without causing appreciable injury to the epidermis. There is marked reduction in recuperative time following nonablative laser rejuvenation, compared with ablative techniques. Because there is significantly less postoperative edema and erythema, patients can be treated and return to work the same day. In addition, there is much less pain associated with the procedure, essentially eliminating the requirements for periprocedural anesthesia. Although these nonablative technologies have been shown to diminish rhytids to a variable degree the dermal remodeling effect is not as significant or pronounced as ablative modalities. The nonablative technologies are not as efficacious as the carbon dioxide or Er:YAG lasers for reduction of moderate and severe rhytids, but can be ideal for modest cutaneous improvement in patients with early photoaging, who desire little or no downtime following the procedure.

The most effective modalities for nonablative facial rejuvenation use mid-infrared lasers, such as the 1320-nm neodymium:yttrium-aluminum-garnet (Nd:YAG) laser or the 1064-nm Q-switched Nd:YAG laser. Mid-infrared laser light penetrates to the papillary and upper reticular dermis to promote collagen remodeling in the dermis, while bypassing the epidermis. However, there is still nonselective heat transfer to the epidermis. Combining these lasers with a cooling mechanism for the skin surface helps

limit epidermal injury. Cooling is accomplished in several ways: nondynamic precooling of the skin, a dynamic coupling of the laser pulse with a cooling cryogen, and/or skin cooling delivered immediately after the laser pulse delivery (quenching). This allows for better control of the surface temperature, maintaining skin temperatures from 40°C to 48°C, while allowing dermal temperatures to reach 60°C to 70°C, at which thermal-induced activation of dermal fibroblasts and dermal remodeling can occur. Cooling protects the epidermis and reduces the risk of pigmentary changes and scarring, even in Fitzpatrick skin types IV and V.¹¹

In sum, many options are available to improve the effects of aging on facial skin. Botox and laser facial rejuvenation are two of the most common nonsurgical adjuncts in the treatment spectrum. When selecting a treatment modality, it is important to assess each patient to ascertain both the etiology of their senescent skin pathology and their expectations of treatment. The physician must appropriately match these expectations with the technique most likely to effect the desired change. Frank communication and education of the patient is essential for directing patient expectations. As in all cosmetic procedures, proper patient selection is key to a successful outcome.

Quiz



1. Vertical, dynamic wrinkles in the glabellar region of the forehead are best treated with

- a. nonablative laser facial rejuvenation therapy with the Nd:YAG laser.
- b. Botox injection of the frontalis muscles.
- c. ablative laser resurfacing with the Er:YAG laser.
- d. Botox injection of the corrugator muscles.

2. The most effective treatment of lax jowling along the lower border of the mandible would be

- a. Botox injection of the orbicularis oris muscle.
- b. a surgical rhytidectomy procedure.
- c. topical retinoic acid treatment.
- d. ablative laser resurfacing with the pulsed CO₂ laser.

3. Photodamage of the skin is evidenced by

- a. blepharoptosis of the eyelids.
- b. lipoatrophy in the cheeks.
- c. solar keratoses on the forehead.
- d. laugh lines around the mouth.

Answers:

- 1. d
- 2. b
- 3. c

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