Correction of surface deformities: Botox, soft-tissue fillers, lasers and intense pulsed light, and radiofrequency

Suzan Obagi, MD

The Cosmetic Surgery and Skin Health Center, University of Pittsburgh Medical Center, Blasmore II, 1603 Connessay Court, Suite 103, Pittsburgh, PA 15214, USA

Skin is by far the largest and most visible organ in the body. Patients seek treatment of cutaneous conditions more readily than of systemic illnesses. How we are perceived or how we perceive others is influenced heavily by appearance. More importantly, the skin plays a vital role in physical attraction. Physical attraction translates into discrepancies between the treatment of attractive versus unattractive individuals in the workplace and social settings. This is no better manifested than by the pressure that celebrities and newscasters feel to look their best to remain competitive in their work environment.

While the interest in cosmetic surgery grows, patient interest in minimally invasive procedures is also on the rise. With many female patients in the workplace, few of them wish to spend their vacation time recuperating from surgery. Interest in minimally invasive cosmetic surgery also is growing among male patients who otherwise may not have contemplated surgery. Along these lines, technology for minimally invasive procedures has grown rapidly, and procedures such as botulinum toxin injections, soft-tissue fillers, and radiofrequency and laser therapies have become widespread. Of concern, however, is that patients no longer rely on a physician as a sole source of information. Instead, they gather much of their information, or misinformation, from the Internet, television, and popular magazines. The role of the surgeon is to sort out the information they bring in and advise patients about the choice of appropriate treatment. It is imperative that a cosmetic surgeon stay abreast of these advances.

Botulinum toxin

Botulinum exotoxin (BTX) use has grown rapidly since the introduction of its cosmetic applications. Its popularity stems from the fact that it is relatively easy to learn, patient acceptance is high, and the side-effect profile is acceptable. BTX can be used as a sole modality to soften the appearance of facial rhytides, which makes it attractive for patients who seek a noninvasive treatment. It also can be used to prolong the results of soft-tissue fillers, skin resurfacing procedures, and certain surgeries.

Properties

BTX has been used for many years to treat conditions of muscle spasticity (eg, strabismus, cervical dystonia) but most recently has become an increasingly popular aesthetic treatment of facial hyperdynamic lines. Botulinum toxins are derived from various strains of Clostridium botulinum, and there are seven serotypes of botulinum toxin: A, B, C1, D, E, F, and G. Each of these serotypes differs in its mechanism of action and clinical response. Their clinical effects,
however, come from the chemodenervation of skeletal muscles by acting on the neuromuscular junction to block the release of acetylcholine.

The two formulations of botulinum toxin available in the United States are botulinum toxin type A (BTX-A; Botox) and botulinum toxin type B (BTX-B; Myobloc). Dysport is the BTX-A available in Europe, and the manufacturer soon may be applying for approval with the US Food and Drug Administration (FDA). BTX-A and BTX-B work by different mechanisms of action and overcome the issue of cross-resistance to the toxin.

BTX-A consists of three proteins: a pure neurotoxin “core” protein, a hemagglutinin protein, and a non-toxic, non-hemagglutinin protein. BTX-A cleaves snapinosome-associated protein 25 to inhibit the release of acetylcholine. BTX-B targets vesicle-associated membrane protein, which is located on the acetylcholine vesicle.

Current clinical studies that evaluate the efficacy of BTX-B show that BTX-B has a rapid onset of action with much more of a “freeze” of the targeted muscle. Current dosing regimens suggest that 100 U of BTX-B are equivalent to 1 U of BTX-A. Even at that dose, however, the duration of action of BTX-B remains shorter than that of BTX-A. Myobloc also has a pH of 5.6, which makes it much more acidic than Botox. Injections of Myobloc are associated with less patient discomfort. No studies have determined whether the addition of sodium bicarbonate to make Myobloc less acidic would alter its effectiveness.

The benefit of BTX-B currently is for patients who are resistant to BTX-A or have a short amount of time before an important social event (BTX-A takes 7–10 days for its peak effect). Combination injections of BTX-B and BTX-A can be used to take advantage of the benefits of BTX-B for a more rapid onset of action and of BTX-A for a longer duration of action.

Currently, Botox comes in a vial with 100 U of freeze-dried BTX-A, which must be refrigerated until used. The vials no longer must be kept frozen. Dysport is packaged with 500 U of freeze-dried BTX-A. The current equivalency of Botox to Dysport is 1 U to 3 to 5 U, respectively. Reconstitution is recommended with preservative-free saline, with care taken to minimize agitation of the solution. The duration for which the reconstituted solution is stored is controversial, with most surgeons using the solution within 24 hours. Contradictory studies show either a loss of efficacy quickly after 24 hours or no difference in 30-day-old solution. A recent multicenter, double-blind study evaluated the efficacy of reconstituted BTX-A (Botox) that was initiated within 1, 8, 15, 22, 29, 36, and 43 days old. The BTX-A was reconstituted with preservative-free 0.9% saline and refrigerated at 4°C. Sixty-five patients completed the evaluation at day 120 (76.4%), and the authors found no difference among patients in terms of efficacy. Clinical results become evident within 1 to 2 days and peak at 7 to 10 days. The results typically last 3 to 4 months and occasionally up to 6 months.

Myobloc comes in vials that contain 2500, 5000, or 10,000 U; however, the bottles are overfilled and actually contain 4100, 6800, and 12,650 U, respectively. No reconstitution or refrigeration is necessary.

Injection techniques

Knowledge of facial anatomy is critical to achieving aesthetic results while minimizing complications. Achieving a “natural” look should be the goal of treatment and not a “frozen” appearance (Fig. 1). Patients are asked to minimize systemic agents that can increase the risk of bruising from injections. They are given instructions to follow for 4 hours after injections. They are asked not to lie down, bend over, or rub the area, and they are asked to contract the injected muscle every 15 to 20 minutes to increase uptake of the BTX into the desired muscle groups.

To minimize the loss of BTX in the “dead space” of the needle hub, most physicians use insulin syringes with a 30-gauge needle attached without a hub (0.3-mL, 0.5-mL, or 1-mL B-D Ultrafine II syringes). Although some physicians use an electromyographic device to identify and inject the desired muscles, familiarity with the facial anatomy and the relatively quick learning curve associated with injections make the use of this device unnecessary.

Glabellar lines (frown lines) are created by the action of the procerus and corrugator muscles. Injection techniques vary from three to seven injections to address these muscles. The procerus muscle is injected at the radix of the nose. Each corrugator muscle is injected using one to three injection sites while holding a finger at the orbital rim to keep the muscle positioned above it.
Dosing for this muscle group ranges from 12 to 35 U of Botox for female patients and 18 to 80 U for male patients. With higher dosing regimens, however, the incidence of blepharoptosis increases dramatically.

Frontal rhytides are created by overaction of the frontalis muscle. The frontalis muscle is the only muscle that directly elevates the brow and affects the shape and height of the brow. Before injection of the frontalis muscle, the patient must be assessed for the presence of brow ptosis. The overuse of the frontalis muscle may stem from a functional need to elevate a ptotic brow to allow for unimpeaded vision. Overzealous treatment of the frontalis muscle may result in brow ptosis, which leaves the patient looking tired and dissatisfied with the treatment. In female patients, an aesthetic appearing brow shows a nice, gradual elevation from the medial aspect of the brow peaking at the start of the lateral third of the brow. At the lateral third of the brow, the brow shows a slight downward curvature. To avoid blunting this curvature, it is important to minimize the injection of the lateral aspect of the frontalis muscle. The corrugator, procerus, and orbiculares oculi muscles act as brow depressors. Selective injection of the frontalis muscle along with the injections of the brow depressor muscles can result in elevation of the brow into a more aesthetic position (Fig. 2). The lateral orbiculares muscle is injected at the temporal fusion line to decrease lateral brow depression. For the frontalis muscle, doses range from 4 to 20 U of Botox.
Crow's feet are addressed by injecting the orbicularis oculi muscles in a semi-lunar pattern (Fig. 3). Ten to 15 U of Botox are injected in two to five sites per side. Care is taken to maintain a 1-cm distance from the lateral orbital rim to avoid diplopia from the inadvertent injection of the lateral rectus muscle. Two U of Botox can be injected approximately 5 mm below the lash line at the mid-pupillary line of the lower eyelid to widen the vertical aperture of the eyes when smiling and to minimize the appearance of the orbicularis roll.

The periocular region can be treated to improve the appearance of radial periocular rhytides by injecting the orbicularis oris muscle with small doses (2 U) of Botox. In this region, care should be taken to make sure that the upper or lower lip is injected in a symmetrical fashion. For example, if the upper lip is injected to address the most prominent rhytid, the identical site on the other side of the upper lip should be injected to maintain balance. Too many injections or too high a dose can result in difficulty drinking from a cup or straw, difficulty articulating certain words, and an altered smile. It is better to inject a small amount and perform a touch-up injection after 10 days rather than overdo it from the start. The depressor anguli oris muscle also can be injected to improve the appearance of the marionette lines (melomental folds) and allow for slight elevation of the oral commissure.

Injection of platysmal bands is becoming more and more popular. Vertical platysmal bands are injected with a vertical line of three injections per muscle band (Fig. 4). Dosing ranges are from 2 to 8 U per injection. Horizontal bands (necklace lines) are also injected in a horizontal pattern of two rows (one above and one below each wrinkle) of three to four injections per rhytid (Fig. 5). Dosing in this region ranges from 2 to 4 U per injection.
Complications

Although there are many different dosing regimens to address the facial musculature, there are several salient points for minimizing complications. The injection of BTX is associated with a variable degree of diffusion to surrounding tissue. Higher concentrations of BTX allow for more accurate placement with less diffusion. Many physicians use 1 mL, 2 mL, or 2.5 mL dilutions. Beyond 2.5 mL dilution, the volume necessary to inject each unit of BTX becomes greater. Contraindications to treatment include are pregnancy, lactation, neuromuscular disease, and the presence of an active infection at the site of injections. Concomitant use of penicillamine, quinine, aminoglycosides, and calcium channel blockers can potentiate the effects of BTX.

Idiosyncratic reactions, such as nausea, headache, fatigue, malaise, flu-like symptoms, and rashes, have been reported. These reactions may be caused by some of the toxin diffusing into the circulatory system. Site-specific complications also are related to the anatomic area treated: brow (brow ptosis), glabella (blepharoptosis) (Fig. 6A), crow's feet (asymmetric smiles if the zygomaticus muscles are injected), perioral region (lip asymmetry, altered smile, and drooling),

Fig. 4. (A) Vertical platysmal bands. (B) Same patient 2 weeks after Botox injection of the platysmal bands. (C) Injection sites and doses (U) for injection of the platysma.
depressor anguli oris muscle (altered smile) (Fig. 6B), nasolabial folds (lip droop), and neck (dysphonia and dysphagia).

**Soft-tissue filling agents**

Soft-tissue augmentation has been used to address various indications, such as rhytides, certain types of scars, and augmentation of the lips. The number of filler agents has increased dramatically overseas, with several of these agents currently pending evaluation and approval by the FDA. The simplest manner in which to characterize filler substances is absorbable versus permanent. An alternative manner in which to characterize fillers is according to their components (Table 1). Because the list of fillers is extensive, this article focuses on the most commonly used agents.

Special factors to take into consideration when selecting the appropriate agent for a patient include longevity of the filler, the anatomic area to be treated, depth of the defect, risks of allergic reaction, risk of delayed (granulomatous) reactions, and risk of infection.

Although the amount of swelling and bruising varies from patient to patient and with the type of filler being used, all patients are advised to avoid aspirin, non-steroidal anti-inflammatory agents, high doses of vitamin E, and certain herbal supplements for at least 10 days before the procedure (Box 1). Cleansing the area to be treated with alcohol suffices for most injectable agents. The use of an implanted device, such as expanded polytetrafluoroethylene, requires the use of a sterile preparation and draping, however. The need for topical or local anesthesia also varies with the type of injectable agent. Some agents are premixed with lidocaine and can be injected with a 30-gauge needle, which is more tolerable for patients. Conversely, some agents require the use of 16- or 18-gauge needles, which require some form of

**Fig. 6.** (A) Blepharoptosis caused by Botox. (B) Asymmetry of the lips during smiling caused by asymmetrical injection of the depressor anguli oris (which was improved by injection of more Botox into the left depressor anguli oris).
nerve blocks or local anesthesia. Injections are best performed with the patient semi-upright to visualize better the rhytides, because lying recumbent alters the appearance of the area to be treated.

Contraindications to the use of certain fillers also vary from one material to the next. The initial patient history should question the tendency for keloid scarring, allergy to local anesthesia (especially lidocaine), history of autoimmune diseases, active infection at the treatment site, and known allergy to any component of the injectable agent. The glabellar region should be treated with care because of the higher risk of skin necrosis in that area.

<table>
<thead>
<tr>
<th>Filler agent</th>
<th>FDA approval</th>
<th>Component</th>
<th>Longevity of effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthetic fillers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bioplastique</td>
<td>No</td>
<td>Dimethyl siloxane particles 150 μm suspended in a polyvinylpyrrolidone carrier, which expands 10% - 20% in 6 weeks</td>
<td>Permanent</td>
</tr>
<tr>
<td>Reviderm Intra</td>
<td>No</td>
<td>Hyaluronic acid and dextran microbeads (biodegradable)</td>
<td>Longest lasting of the temporary fillers</td>
</tr>
<tr>
<td>Canderm Pharma</td>
<td>Pending</td>
<td>75% bovine collagen in a 25% polymethylmethacrylate microbead suspension 40-80 μm</td>
<td>Permanent</td>
</tr>
<tr>
<td>Artecoll (Aretill)</td>
<td>Pending</td>
<td>Calcium hydroxyapatite microspheres stimulates innate collagen formation</td>
<td>12 - 15 months after serial injections</td>
</tr>
<tr>
<td>Refill Medical International</td>
<td>Pending</td>
<td>Polyactic acid microspheres</td>
<td>2 - 5 years</td>
</tr>
<tr>
<td>AdatoSIL 5000</td>
<td>Yes for ocular use</td>
<td>Medical-grade silicone 5000 centistokes</td>
<td>Permanent</td>
</tr>
<tr>
<td>Silikon 1000</td>
<td>Yes for ocular use</td>
<td>Medical-grade silicone 1000 centistokes</td>
<td>Permanent</td>
</tr>
<tr>
<td>Hyaluronic acid</td>
<td>Yes for Restylane; pending for Perlane</td>
<td>Hyaluronic acid derived from bacterial fermentation</td>
<td>Up to 1 year</td>
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<td>Restylane/Perlane</td>
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<td></td>
<td></td>
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<tr>
<td>Q-Med</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hylaform</td>
<td>Pending</td>
<td>Rooster comb derived</td>
<td>3 - 6 months</td>
</tr>
<tr>
<td>Inamed Aesthetics</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Human derived</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fascian</td>
<td>Yes</td>
<td>Lyophilized fascia lata from donor cadavers with variable particle sizes available (0.1-2 mm) or fine sheets, which may be trimmed to size</td>
<td>Up to 6 months</td>
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<td>Fascia Biosystems</td>
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<td></td>
<td></td>
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<tr>
<td>Cosmoderm/Cosmoplast</td>
<td>Yes</td>
<td>Human fibroblast culture-derived collagen</td>
<td>Up to 6 months</td>
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<tr>
<td>Inamed Aesthetics</td>
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<td></td>
<td></td>
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<tr>
<td>Cymetra</td>
<td>Yes</td>
<td>Micronized Alloderm stimulates innate collagen formation over time</td>
<td>Many months after serial injections</td>
</tr>
<tr>
<td>LifeCell Corp</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Zyderm 1, II/Zyplast</td>
<td>Yes</td>
<td>Bovine collagen</td>
<td>Up to 6 months</td>
</tr>
<tr>
<td>Inamed Aesthetics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UltraSoft Implants</td>
<td>Yes</td>
<td>ePTFE (Gore-Tex) Thinner wall thickness, tubular or prelit</td>
<td>Permanent but removable</td>
</tr>
<tr>
<td>Tissue Technologies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Advanta Implants</td>
<td>Yes</td>
<td>ePTFE Hybrid of high-density and low-density ePTFE walls</td>
<td>Permanent but removable</td>
</tr>
<tr>
<td>Atrium Medical Corp</td>
<td></td>
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</tbody>
</table>

Abbreviation: ePTFE, expanded polytetrafluoroethylene.
Box 1. Medications, supplements, and foods that may increase bruising

Foods with aspirin-like properties
Apples
Apricots
Avocados
Blackberries
Cherries
Currants
Cucumbers
Dewberries
Fish (All types)
Garlic
Gooseberries
Grapefruit
Grapes
Lemons
Melons
Nectarines
Oranges
Onions
Peaches
Peppers (Bell/green)
Plums
Potatoes
Prunes
Raisins
Raspberries
Root beer
Shellfish (all types)
Spicy foods
Strawberries
Sunflower seeds
Soybeans
Sweet potatoes
Tomatoes
Wheat germ oil

Herbs that contain aspirin properties or increase blood pressure* or monoamine oxidase inhibitors**
Cayenne (red pepper)
Feverfew
Garlic
Gingko
Ginger
Ginseng*
Guarana
Kava Kava**
Meadowsweet
St. John’s Wort**
Turmeric
Vervain
White Willow
Other products that increase bleeding times
Fish oil
Garlic supplements
Niacin
Vitamin E (<200 IU)

Medications
Aspirin
Ibuprofen (Advil, Motrin) / nonsteroidal anti-inflammatory drugs in general
Naprosyn/naproxen (Aleve)

Human bioengineered collagen

CosmoPlast and CosmoDerm (Inamed Aesthetics, Santa Barbara, California)

CosmoPlast and CosmoDerm-I are derived from human foreskin fibroblast culture. These agents received FDA approval in March 2003 for the treatment of facial wrinkles, acne scars, and soft-tissue contour deficiencies. CosmoDerm-II (65 mg/mL) is still pending FDA approval. CosmoDerm-I contains 35 mg/mL of collagen type 1 and 0.3% lidocaine. CosmoDerm-I is used for the treatment of superficial wrinkles in a manner similar to Zyderm I for the treatment of forehead lines, glabellar lines, crow’s feet, perioral rhytides, and scars. This filler is placed into the superficial dermis with a slight degree of overcorrection. One should see a slight blanching of the skin at the site of placement.

CosmoPlast contains 35 mg/mL of collagen cross-linked with glutaraldehyde in a phosphate-buffered saline-containing lidocaine 0.3%. It is used for deeper lines, such as nasolabial folds, marionette lines, deep scars, and vermilion border of the lips. Placement of this filler should be in the upper-to-middle dermis. If it is placed too deeply, such as in the subcutaneous fat, it is absorbed quickly. Conversely, superficial placement results in visible white lumps. CosmoDerm can be layered over CosmoPlast to address the superficial and deep aspects of a rhytid. A 30-gauge needle is used for the placement of either of these substances.

Fascia (Fascia Biosystems Beverly Hills, California)

Fascia lata has been used extensively in surgery for eyelid repairs, hernia operations, and reconstructive procedures. Fascia lata is preserved particulate cadaveric fascia lata. It comes in powder-filled 3-mL syringes (80 mg) in five particle sizes (0.1, 0.25, 0.5, 1.0, and 2.0 mm). Before injection, Fascia lata is rehydrated with 3 mL of 1% lidocaine. It is injected just below the dermis into the superficial subcutaneous fat with 16- or 18-gauge needles. Slight overcorrection is recommended to account for the absorption of the lidocaine solution.

Bovine collagen

Zyplast and Zyderm

Zyplast I, Zyplast II, and Zyderm are similar in concentration to CosmoDerm and CosmoPlast, except that they are bovine collagen derived. For this reason, skin tests must be given to detect patients who may have a delayed hypersensitivity reaction (Fig. 7). The risk of an allergic reaction to bovine collagen occurring despite one negative skin test is 1.3% to 6.0%. The administration of a second test 2 weeks later can lower the risk to 0.5%, however. Placement of these materials is in a fashion similar to their human-derived counterparts (Figs. 8–13).
Fig. 7. Allergic reaction to a bovine collagen skin test.

**Synthetic fillers**

**Silicone**

Two FDA approved silicone agents are on the US market: AdatoSil 5000 and Silikon 1000. Both agents are approved for intraocular injections. Silikon 1000 is less viscous and easier to inject compared with AdatoSil 5000 because Silikon 1000 takes 1000 centistokes to inject compared with 5000. Neither of these agents matches the ease of injection of older, 350-centistoke agents, however. SilSkin (Richard-James Inc, Fort Worth, Texas) is another 1000 centistoke silicone product currently seeking FDA approval for the treatment of facial rhytides.

Fig. 8. Injection techniques for Zyderm, Zyplast, CosmoDerm, and CosmoPlast. (A) Threading technique to infiltrate the vermillion of the lips. Bending the 30-gauge needle at a slight angle helps to position better the placement of the filler. (B) Threading technique to treat perioral rhytides. Zyplast and CosmoPlast should be placed deeply enough so that blanching of the skin is not seen on injection. (C, D) Threading technique to treat the nasolabial folds.
Fig. 9. (A) Same patient in Fig. 10 before injection of the perioral rhytides, nasolabial lines, and vermillion with Zyplast. (B) Patient 3 weeks after injection shows softening of the nasolabial folds and improvement in the perioral rhytides.

Fig. 10. (A) Patient before Zyplast injection of the upper and lower lip vermillion and body. (B) Same patient 1 week after injection shows better definition of the vermillion and fuller, more proportional lips.

Fig. 11. (A, B) Same patient in Fig. 12 seen from the lateral oblique view.
These new agents are medical-grade silicone. The injections of these substances are recommended in a microdroplet technique. Placement of small aliquots allows a fibrous reaction to form around the silicone over the ensuing few weeks, which results in further soft-tissue augmentation. For this reason, overcorrection is not desired; otherwise the patient may develop visible lines or lumps. The risk of granuloma formation (Fig. 14) with the newer silicone agents is not yet known. It is prudent to check with a malpractice carrier before using these agents because many carriers exclude coverage for silicone injections.
New-Fill (Dermik Laboratories)

New-Fill is a polylactic acid filler currently pending FDA approval. Cosmetically, it has been used widely in Europe, South America, and Australia since 1997. Medically, however, it has been used for more than 40 years as a component of dissolvable suture material and more recently in orthopedic surgery in the form of bone plates and screws. It is composed of 40 to 60 microspheres of polylactic acid lyophilized into a powder that is then reconstituted with 3 to 6 mL of preserved saline, lidocaine, or nonpreserved saline. European physicians report a 12- to 15-month retention in patients after a series of two to three injections of 2 to 4 mL monthly.

Injections are performed in a retrograde threading technique using a 26-gauge needle attached to a 1- or 3-mL syringe. A crisscross or lattice technique is used to cover the area treated, with placement of the material into the deep dermis. Undercorrection by at least 30% is recommended to allow for additional collagen formation around the microspheres.

Side effects include erythema and edema, which last 3 to 4 days in all patients; 10% to 15% of patients get bruising that lasts up to 1 week, and less than 1% of patients develop 1- to 2-mm size nodules, especially along the orbital rim injections.

Artectoll (Artiell)

In Europe, polymethylmethacrylate (PMMA) beads have been used for more than 12 years, most recently as a product called Artectoll, which is currently pending FDA approval under the name Artefill. The FDA already has given preliminary approval but requires some form of patient monitoring for approximately 5 years to evaluate the incidence of long-term complications, such as granuloma formation. This requirement arises from a 5-year time period from 1989 to 1994, when there was a surge in foreign-body reactions in the first-generation product Arteplast. Subsequent purification techniques have reduced successfully the incidence of this reaction to 0.01% or 1 in 10,000 patients. The FDA also may require the institution of a physician training program to ensure that physicians are trained in the correct injection techniques of this permanent filler before allowing them to purchase the product.

Artefill consists of synthetic PMMA microspheres, 30 to 40 μm in diameter, which are suspended in bovine collagen. The collagen component is used simply to deliver an even suspension of the PMMA beads into the soft tissue and is then resorbed, leaving behind the PMMA beads. The PMMA microspheres act as a scaffold for neocollagenesis over the ensuing few months. The end result is a collagen matrix that consists of 80% of the patient's own collagen and 20% microspheres. Artefill is considered to be an ideal agent for treating highly mobile areas, such as the nasolabial folds and perioral rhytides, because mobility accelerates the absorption of most biodegradable fillers. Because Artefill contains bovine collagen, test
injections are required before treating patients to exclude patients with bovine hypersensitivity reactions.

**Hyaluronic acid**

Hyaluronic acid is a ubiquitous component of connective tissue and synovial tissue and fluid. It is a glycosaminoglycan biopolymer composed of alternating residues of D-glucuronic acid and N-acetyl-D-galactosamine that can bind up to 10,000 times its weight in water. Its affinity for water molecules gives it a unique ability to add to skin turgor and volume. Because it is identical in chemical and molecular form across all living organisms, it is highly biocompatible and species nonspecific. Injection of unmodified hyaluronic acid results in almost immediate degradation, however. For hyaluronic acid to be a clinically useful injectable filler, it must undergo cross-linking to confer longevity.

Its popularity stems from the ease of injection, low rate of hypersensitivity reactions, and product longevity superior to collagen injections. Although it is one of the most popular agents for soft-tissue augmentation in Europe, the FDA only recently approved one form of hyaluronic acid in the United States. Restylane (Medicis in the USA, Q-Med, Uppsala, Sweden) received FDA approval for the treatment of superficial rhytides. Hylaform is a rooster comb-derived hyaluronic acid currently being evaluated by the FDA.

Restylane, Restylane Fine Lines, and Perlane are hyaluronic acids derived from bacterial fermentation. All three formulations contain stabilized hyaluronic acid at 20 mg/mL, with the only difference being the size of the injected particles. Restylane Fine Lines contains 200,000 particles/mL, Restylane has 100,000 particles/mL, and Perlane has 10,000 particles/mL. Although Perlane has fewer particles per milliliter, the size of the particles is much larger than that of Restylane and Restylane Fine Lines. This difference accounts for the longevity of the Perlane injection compared with the others. This is also the reason that Perlane is limited for use in the deep dermis and subcutaneous fat, however. More superficial placement results in visible papules and nodules. None of the hyaluronic acid agents contains lidocaine, so some type of local anesthesia is required.

Restylane is injected into the mid-dermis using a 30-gauge needle. Perlane is placed into the deeper dermis using a 27-gauge needle. Injection of Perlane too superficially may result in visible bumps. Layering of these two agents can be used to address the deep and superficial components of rhytides. Either agent can be placed using a threading technique or a serial puncture technique.

Complications include visible papules from too superficial placement, mild bruising that lasts 4 to 7 days, edema, and arterial embolization from intravascular injections. There have been reports of hypersensitivity reaction in approximately 1 in 2000 patients.

**Radiance and Radiance FN (Bioform, Franksville, Wisconsin)**

Calcium hydroxyapatite is the building block of teeth and bone. It has been used for years in orthopedic surgery for the correction of bone defects. In soft tissue, its initial uses were for soft-tissue marking, because Radiance is radiopaque. Although the agent is radiopaque, it has not been found to interfere with the reading of dental radiographs. It is injected into the deep dermis with no overcorrection. A fibroblast reaction results in the formation of collagen over time. Special care should be taken when using this agent for lip augmentation to avoid the formation of visible or palpable nodules. It is not an agent of choice when a surgeon is relatively new to lip augmentation procedures.

**Implants**

**Expanded polytetrafluoroethylene**

Expanded polytetrafluoroethylene is a biocompatible, inert, permanent tissue implant that has been used for more than 25 years. Its initial uses were for vascular grafts, but they have
evolved over time to include soft-tissue augmentation of the lips and nasolabial folds. Older implants consisted of solid strips and rolls (Gore-Tex, W.L. Gore & Associates, Inc., Newark, DE) and have evolved to tubes of various lengths and diameters (UltraSoft, Advanta Implants, Atrium Medical Corporation, Hudson, New Hampshire). These thinner-walled tubular structures were designed to allow for ingrowth of fibrous tissue through the lumen while minimizing the ability to palpate the implant.

Insertion of the implant requires that either a trocar be used to guide the implant into position or alligator forceps be used for pretunneling and grasping the implants. Incisions are made in the skin to allow for insertion of the forceps or trocar. The implants are placed in the upper subcutaneous fat, parallel to the overlying defect or rhytid. Before closing the incisions, the ends of the implants are cut to form tapered edges and are buried subdermally.

Benefits of expanded polytetrafluoroethylene implants are that they retain their original size, thickness, strength, and pliability after insertion. Should the need arise to remove the implant, it is relatively easy to do so in a fashion similar to placing it. The longer the implant has been in place, however, the more fibrosis there is around it, which makes it more difficult to remove. Complications associated with the use of expanded polytetrafluoroethylene devices include extrusion, palpability, infection, and the possibility of migration.

Other

Autologous fat augmentation

The search for the ideal filler continues. Autologous fat has the advantages of being non-immunogenic, fairly abundant, and a living tissue with the potential for permanent augmentation. Much of the debate over its use arises from the fragility of the adipocyte, however, which predisposes it to damage during harvesting, preparation, and implantation. Many techniques have been tried with varying results.

Two methods show relatively long-lasting and reproducible results: Dr. Sydney Coleman’s structural fat grafting and Dr. Roger Amar’s fat autograft muscle injection technique. Although the names may be different, the techniques have many similarities. In both cases, atraumatic harvesting of the fat is paramount. The fat is then centrifuged for 3 minutes at 3000 rpm and transferred to 1-mL syringes via luer-to-luer connections. Blunt cannulae are used to place tiny parcels of fat in multiple planes in the face: along the periostea (Dr. Coleman’s technique), the muscles (both techniques), and in the subdermal plane (both techniques).

By placing small parcels of fat into healthy, vascular tissue such as muscle, there is more chance for the fat to re-establish its blood supply and survive. Results of these techniques have been encouraging and have a high patient satisfaction rate (Fig. 15).

Fig. 15. (A) Patient with malar atrophy, prominent nasolabial and melolental folds. (B) Same patient 11 months after one session of autologous fat augmentation of the malar region and nasolabial fold and two sessions of fat augmentation of the melolental folds. Liposuction of the jowls also was performed at the first surgery.
Lasers, intense pulsed light, and radiofrequency devices

The field of lasers and laser-like technologies has revolutionized the treatment of various skin signs of aging. The rapid pace at which technologic advances are occurring is matched only by consumer interest, which is fed by all aspects of the media. Patients are opting for noninvasive treatment of rhytides, lentigines, and telangiectasias over older lasers, which required considerable recovery times. Most patients do not want the prolonged recovery, months of erythema, and possibility of permanent hypopigmentation seen with carbon dioxide resurfacing lasers. Younger patients and patients who are afraid of surgery are also quick to embrace these procedures. A complete description of each individual device is beyond the scope of this article. A general approach to these devices is presented based on their clinical indications. Table 2 summarizes these devices.

Laser is an acronym for light amplification by the stimulated emission of radiation. Lasers operate by emitting a single wavelength of light that is preferentially absorbed by a particular chromophore in the skin (Fig. 16). Intense pulsed light (IPL) systems emit various wavelengths from 400 to 1200 nm but are controlled by using various cut-off filters.

<table>
<thead>
<tr>
<th>System</th>
<th>Wavelength(s) (nm)</th>
<th>Pulse Duration</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPL (pulsed light)</td>
<td>400-1200</td>
<td>5-100 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hair removal, Lentigines</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vascular lesions</td>
</tr>
<tr>
<td>LED</td>
<td>410</td>
<td>N/A</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Copper bromide</td>
<td>511 and 578</td>
<td>10-900 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Vascular lesions</td>
</tr>
<tr>
<td>KTP</td>
<td>532</td>
<td>N/A</td>
<td>Pigmented lesions</td>
</tr>
<tr>
<td>Diode</td>
<td>532</td>
<td>0-100 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Q-switched Nd:YAG</td>
<td>532</td>
<td>&lt;20 ns</td>
<td>Pigmented lesions</td>
</tr>
<tr>
<td>(frequency doubled)</td>
<td></td>
<td></td>
<td>Tattooed, orange, yellow</td>
</tr>
<tr>
<td>Pulsed dye</td>
<td>585</td>
<td>0.45 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td></td>
<td>595</td>
<td>0.45-40 ms</td>
<td>Vascular lesions</td>
</tr>
<tr>
<td></td>
<td>585-595</td>
<td>0.5-40 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Q-switched ruby</td>
<td>694</td>
<td>20-50 ns</td>
<td>Vascular lesions</td>
</tr>
<tr>
<td>Q-switched alexandrite</td>
<td>755</td>
<td>50-100 ms</td>
<td>Pigmented lesions, Tattooos blue,</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>black, green</td>
</tr>
<tr>
<td>Alexandrite</td>
<td>755</td>
<td>5-50 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Diode</td>
<td>800-810</td>
<td>5-400 ms</td>
<td>Hair removal</td>
</tr>
<tr>
<td>Q-switched Nd:YAG</td>
<td>1064</td>
<td>&lt;20 ns</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pigmented lesions, Tattooos blue,black</td>
</tr>
<tr>
<td>Nd:YAG</td>
<td>1064</td>
<td>0.4-300 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Hair removal, Vascular lesions</td>
</tr>
<tr>
<td>Diode</td>
<td>1320</td>
<td>400 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Erbium:glass</td>
<td>1450</td>
<td>250 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Radiofrequency</td>
<td>1540</td>
<td>3.3 ms</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>Erbium: YAG</td>
<td>N/A</td>
<td>N/A</td>
<td>Nonablative rejuvenation</td>
</tr>
<tr>
<td>CO₂</td>
<td>2940</td>
<td>N/A</td>
<td>Skin resurfacing</td>
</tr>
<tr>
<td>Blended Erbium:YAG</td>
<td>10,600</td>
<td>N/A</td>
<td>Skin resurfacing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Skin resurfacing</td>
</tr>
</tbody>
</table>

Abbreviations: KTP, potassium titanyl phosphate; LED, light emitting diodes.
Thermal relaxation time, pulse duration (pulse width), and selective photothermolysis are important concepts in understanding the mechanism behind thermal damage. Once a chromophore has absorbed a light beam, it heats up. The thermal relaxation time refers to the time it takes this light-absorbing object to cool to half of its elevated temperature. Thermal relaxation time is closely related to the square of the size of the object. Smaller objects cool faster than larger ones. If the pulse duration (the duration of the laser emitted light) is shorter than the thermal relaxation time, selective photothermolysis occurs with minimal residual thermal damage. Pulse durations that are longer than the thermal relaxation time of the chromophore cause adjacent tissue thermal damage by dissipation of heat to surrounding tissue. To target a particular chromophore in the skin while minimizing collateral damage, one must select a laser with the appropriate wavelength and pulse duration.

With the exception of carbon dioxide (CO2) and erbium:YAG (Er:YAG) lasers, longer wavelength lasers usually penetrate more deeply into the skin. Er:YAG and CO2 lasers, 2940 nm and 10,600 nm, respectively, have tremendous affinity for water, which results in ablation of the targeted tissue and serves to limit the depth of penetration of the laser beam.

Photoepilation

Permanent hair reduction has increased in popularity among men and women of all racial backgrounds. The best candidates remain patients with light skin coloring with dark, coarse hair (Fig. 17). The typical patient who presents for hair removal is not usually the “ideal” candidate. Often patients have any combination of light or dark skin with thin or coarse hair that may be gray, light, or dark. It is imperative to remember that safe hair removal requires systems that target the melanin within the hair bulb while avoiding absorption of the light beam by epidermal melanin (Fig. 18). Despite the claims that some lasers are designed to be safe on tanned skin, it is still best to ask patients to avoid tanning, including self-tanning, 6 weeks before and during the course of therapy.

Ways to minimize epidermal injury include various methods of epidermal cooling using refrigerated gels, cryogen sprays, and contact cooling devices. Shifting toward a longer wavelength laser (ie, 1064 nm) and increasing the pulse width of the beam (ie, 40 ms) are ways that preferentially target the hair bulb over the epidermis. For effective hair reduction, the pulse width should be in the millisecond range (not nanosecond). Systems with shorter pulse widths (3–10 ms) are better for lighter hair or fair-skinned individuals. Darker skinned individuals require longer pulse widths (20–40 ms) and possibly a longer wavelength (1064 nm over 755 nm).
Hair that is present in the hair bulb is either in a growing phase (10%–20%) or resting phase (80%–90%). Only hairs targeted in the growing phase (anagen hairs) result in long-lasting reduction, whereas the resting phase (telogen) hairs regrow. Multiple treatments are required, with the timing of these sessions coinciding with the earliest signs of hair regrowth.

Future advances include laser systems that have pulse widths of 100 ms arising from studies that show long-term hair reduction without adverse sequelae. The benefit of the 100-ms pulse width is that it may allow for heat diffusion from heavily pigmented parts of the hair bulb to the part of the follicular unit, which does not contain a large amount of melanin. Ongoing studies are evaluating the use of photodynamic therapy to target lightly pigmented hairs. Further refinements in this therapy are necessary before widespread acceptance.

**Vascular lesions**

Patients seek treatment for many vascular conditions. Patients may present with hemangiomas, port-wine stains, spider angiomias, telangiectasias, and rosacea. Increasingly more patients with rosacea are becoming aware that IPL and lasers offer them dramatic improvement of their disease. For many individuals, it is a way to remove the often embarrassing stigmata of this inflammatory disease.

Vascular lasers target oxyhemoglobin as the main chromophore; however, oxyhemoglobin has three peaks along the electromagnetic spectrum: 418, 542, and 577 nm. Lasers that have
been used to treat vascular lesions include potassium titanyl phosphate (KTP), copper bromide, pulsed dye laser (PDL), and Nd:YAG. Argon lasers are no longer commonly used to treat vascular lesions because of the risk of hypopigmentation and scarring. IPL systems are gaining popularity for the treatment of certain telangiectasias, but there is a steeper learning curve with these systems (Fig. 19).

Success results from the correct evaluation of the depth of the lesion being targeted, the vessel caliber size, and the correct wavelength. Larger caliber vessels tend to reside deeper in the dermis and subcutaneous fat. Longer wavelength lasers, such as Nd:YAG, are required to reach this depth. The energy and spot size used are adjusted to the vessel diameter, with larger vessels requiring a larger spot size but relatively less energy. Although useful for the treatment of larger leg veins, these treatments are associated with more discomfort and less clearance than sclerotherapy (which remains the gold standard).

Smaller telangiectasias respond well to KTP, IPL, and PDL. The use of Nd:YAG can be successful if the laser system used allows the pulse width to be shortened and the energy to be increased sufficiently to ablate these more superficial vessels. The use of the shorter wavelength KTP offers the advantage of no purpura. The trade-off, however, is that the depth of penetration is shallow and the absorption of epidermal melanin is high, which limits its use in darker skinned patients.

The newer PDLs offer a 595-nm wavelength compared with the older 585-nm PDLs. The newer PDLs also offer the ability to adjust the pulse width from 0.45 to 40 ms (intervals vary by maker). The advantages of the 585-nm PDLs were the almost indiscriminate occurrence of long-lasting purpura (Fig. 20) and the risk of blistering and hypopigmentation. The modifications made to the 595-nm PDLs have allowed for deeper penetration of the laser beam, which enhances clearance of deeper vessels (Figs. 21–23). The ability to adjust the pulse width allows for titration of the treatment from nonpurpuric to purpuric depending on the endpoint the physician is seeking. The newer PDLs also have some form of dynamic cooling either with a cryogen spray or continuous stream of cold air, which greatly decreases the incidence of blisters and hypopigmentation.

**Pigmented lesions and tattoos**

The advent of Q-switched lasers has dropped the pulse width into the nanosecond range. This change makes these lasers able to deliver high amounts of energy in a short span of time, which is within the thermal relaxation time of melanosomes and tattoo pigments. This results in rapid thermal tissue expansion and photoacoustic mechanical disruption and fragmentation of pigment particles in the dermis.

Q-switched—ruby (694 nm), Q-switched—alexandrite (755 nm), and Q-switched—Nd:YAG (532 or 1064 nm) lasers have been used to successfully treat ephelides, lentigines (Fig. 24), café-au-lait macules, nevus of Ota, Becker’s nevi, infraorbital hyperpigmentation, and certain tattoos. Although 1064 nm falls outside the ideal wavelength for melanin absorption, this wavelength offers a depth of penetration (4–6 mm) more than ruby (1 mm) and alexandrite
lasers, which makes it more useful for deeper lesions. IPL systems have shown efficacy against superficial pigmented lesions such as ephelides and lentigines but have been less effective against lesions that contain dermal pigmentation.

Amateur tattoos are relatively easier to remove than professional tattoos because the pigment tends to be placed more superficially in amateur tattoos. Blue and black pigments respond to laser better than orange and yellow. Extreme caution should be taken with the use of Q-switched lasers in areas of flesh-tone, white, or rust-colored pigments. These pigments contain ferric oxide, which can be reduced irreversibly to ferrous oxide when exposed to the laser beam. Ferrous oxide is a black and insoluble pigment. Patients who have an allergic reaction to a tattoo should not be treated with laser because of case reports of widespread systemic allergic reactions that occurred in patients as a result of systemic dispersal of the pigment after laser irradiation.

**Nonablative photorejuvenation**

Nonablative treatment of scars and rhytides with no recovery time has been a big attraction to patients who seek to improve their appearance without the morbidity associated with ablative

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**Fig. 20.** Example of PDL-induced purpura.

**Fig. 21.** (A) Patient with an extensive PWS of the lateral neck and cheek. (B) Same patient after four sessions of PDL with a 595-nm laser. Note the more rapid clearing of the PWS on the neck as compared with the face. Centrally located PWS are more resistant to treatment as compared with lateral PWS lesions.
Fig. 22. (A) Patient with an extensive port wine stain (PWS) of the cheek and midface. (B) Same patient after numerous PDL treatments with an older 585-nm PDL and the newer generation 595-nm PDL.

Fig. 23. (A) Patient with moderately severe rosacea. (B) Same patient after three sessions of 595-nm PDL. Patient also noted improvement of flushing episodes.

Fig. 24. (A) Patient with lentigines of the forehead. (B) Patient 1 week after QS-Nd:YAG 532-nm laser.
Fig. 25. (A) Patient with prominent perioral rhytides. (B) Same patient after six sessions of Cool Touch 1320-nm laser treatments shows marked improvement in rhytides.

therapies. Currently, three laser systems specifically perform nonablative treatments: 1320-nm Nd:YAG, 1450-nm diode, and 1540-nm erbium:glass. These lasers emit wavelengths in the infrared portion of the electromagnetic spectrum with water-containing tissue as their chromophore. The epidermis is protected by either contact or dynamic cooling, which allows most of the beam to target the dermis. A subclinical dermal injury is induced, which then results in dermal remodeling over the ensuing weeks. Most studies have shown response of periorbital rhytides to be superior to perioral rhytides with the nonablative lasers. Increasingly, these lasers are used in conjunction with Botox injections to enhance results over results seen with lasers alone.

With the trend of nonablative therapies increasing, many other lasers have been used to achieve variable degrees of nonablative photorejuvenation, including 585-nm and 595-nm PDLs, 1064-nm Nd:YAG, and IPL. It seems that the critical point is to achieve some degree of dermal injury (vascular injury or heat injury), which then triggers a wound-healing response with subsequent neocollagenesis.

Fig. 26. (A) Patient with extensive photodamage and rhytides. (B) Same patient 3 months after full-face laser resurfacing with a blended Er:YAG and CO₂ laser.
Although many studies show clinical and histologic improvement in patients who undergo nonablative therapy, the results are at best minimal to moderate (Fig. 25). The gold standard still remains ablative therapy of scars and rhytides. The attraction for patients remains the ability to resume their normal activities without interruption. Because results are moderate at best, patients should be given reasonable expectations to increase satisfaction with these modalities.

Resurfacing lasers

Although nonablative therapies have become a popular trend among patients and physicians alike, the pendulum may be swinging back toward more time-tested techniques. Ablative laser resurfacing remains the gold standard to which these nonablative systems are compared. Two laser systems have been developed for skin resurfacing: CO₂ and Er:YAG. CO₂ lasers have shown tremendous improvement in photodamaged and scarring skin; however, they are associated with prolonged erythema, transient hyperpigmentation, hypertrophic scarring, and permanent hypopigmentation. For this reason, Er:YAG lasers were investigated and found to give improvement in photodamaged and scarring skin but not to the extent seen with CO₂ lasers.

In an attempt to approach further the results of CO₂ lasers, modified Er:YAG systems have been developed. One of the newer Er:YAG lasers allows the use of longer pulse widths (up to 500 μs) to produce a larger zone of thermal necrosis, which comes closer to mimicking that seen with CO₂ lasers. This approach results in deeper tissue penetration and improved coagulation of dermal vessels. Another Er:YAG laser system is a “blend” of CO₂ and Er:YAG (Fig. 26). It can deliver a pulse of energy made up of Er:YAG and CO₂. The percentage of how much of each laser pulse is made up of CO₂ can be adjusted from 0 to 100%. This system also offers more coagulation and tissue tightening than traditional Er:YAG systems.

<table>
<thead>
<tr>
<th>Waveform</th>
<th>Modifications</th>
<th>Clinical Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cut</td>
<td>90% cut</td>
<td>Cuts tissue with little collateral tissue damage</td>
</tr>
<tr>
<td></td>
<td>10% coagulation</td>
<td>Allows for cutting and coagulation if tissue with minimal collateral tissue damage</td>
</tr>
<tr>
<td>Cut/coagulation</td>
<td>50% cut</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50% coagulation</td>
<td></td>
</tr>
<tr>
<td>Hemostasis</td>
<td>10% cut</td>
<td>Allows for direct and indirect hemostasis</td>
</tr>
<tr>
<td></td>
<td>90% coagulation</td>
<td></td>
</tr>
<tr>
<td>Fulguration</td>
<td>Spark gap</td>
<td>Can be used in bipolar or unipolar modes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The large amount of heat damage makes this useful for intentional destruction of tissue</td>
</tr>
</tbody>
</table>
Fig. 28. (A) Bipolar and standard handpiece. Note the presence of buttons on the standard handpiece that correspond with three waveforms: cut, cut/coagulation, hemostasis. (B) Various sizes and shapes of loop tips for removal of lesions. (C) Use of wire tip for fine incisions, such as in blepharoplasty. (Courtesy of Joe Niamtu, III, DDS (Oral Maxillo Facial Surgeon); with permission.) (D) Use of the microneedle for incisions in cosmetic surgery, such as in rhytidectomy. (Courtesy of Constantine Stan, MD (Aesthetic Plastic Surgeon); with permission.)

Radiofrequency devices

The technology of radiofrequency devices has evolved over the years to allow for more indications and flexibility in their use. Surgical and nonsurgical applications of these devices are discussed as they pertain to cosmetic surgery.

Fig. 29. ThermaCool treatment being performed shows the handpiece with negative and positive electrodes on the tip.
Fig. 30. (A) Patient with brow ptosis and lateral hooding of the eyelids before ThermaCool treatment. (B) Same patient 6 weeks after one treatment shows marked improvement in brow ptosis.

Surgical uses

For use in surgery, the optimal radio wave is 4.0 MHz. An example of such a device is the Ellman Surgitron Dual Frequency 4.0 MHz (Fig. 27). These devices take an alternating current and convert it into a direct current, which then passes through a coil/rectifier to generate the radio waves. The shape of the waveform can be modified to produce one of four waveforms useful in surgery (Table 3). The same device can be used for creating an incision and for hemostasis. Radiofrequency devices generate less heat than electrocautery machines, which results in less collateral tissue damage. By minimizing collateral tissue damage, wound healing is not delayed significantly and there is less risk of scarring.

Various tips can be used with this device depending on the clinical indication (Fig. 28). For tissue incisions (e.g., rhytidectomy, blepharoplasty) there are wire tips and tungsten microneedles. For pedunculated lesions, a loop tip (various shapes and sizes) can be used. For hemostasis or the destruction of certain superficial skin lesions (e.g., acrochordons, seborrheic keratoses), a ball electrode can be used.

Advantages of using radiofrequency devices in surgery are similar to the use of CO₂ lasers but with less collateral tissue damage. The radiofrequency device also provides the advantage of giving the surgeon more tactile feedback than laser. The incisions can be made with little to no pressure. Another advantage is the need for fewer safety precautions necessary with these devices compared with lasers. Cure still should be exercised around the intraoperative use of oxygen, and there should be adequate smoke plume evacuation.

Fig. 31. (A) Young patient with early melomental fold formation. (B) Same patient 6 weeks after ThermaCool treatment of the melomental fold shows improvement.
Nonablative uses

An increasingly popular procedure involves the nonablative tissue-tightening effects seen with the recently introduced radiofrequency device, ThermoCool TC (Thermage, CA) (Fig. 29). In a fashion similar to nonablative laser devices, heat is delivered deep into the dermis to create thermal damage, which results in immediate collagen tightening and neocollagenesis over the ensuing 3 to 6 months. The epidermis is kept cool by a constant cryogen spray. The depth of penetration of this device (2500 μm) is greater than that of nonablative lasers currently in use. Although the results of this procedure vary from patient to patient, the clinical effects on actual tissue tightening are more dramatic than those seen with nonablative lasers (Figs. 30, 31). Nonablative lasers seem to induce clinical improvement in superficial scars and rhytides, whereas this device seems to exert little effect on superficial defects while inducing more of a deep effect, which translates clinically into the tightening that is seen. To address the issue of superficial defects, the company is currently developing new tips that will have less depth of penetration.

Currently, another device, Aurora (Syneron, Ontario, Canada), a combination IPL and radiofrequency device that is FDA approved for hair removal, is being evaluated for use in nonablative rejuvenation.

Summary

The field of cosmetic surgery continues to be a rapidly changing and expanding one. With the understanding of the changes that take place in aging and contribute to photodamaged skin, technologic advances have become more based in science. Patients are aware of these changes and are enthusiastically tracking them through all media channels. It has become more important than ever for surgeons to stay abreast of this new knowledge.

Further readings

Carruthers J, Carruthers A. A prospective, randomized, parallel group study analyzing the effect of BTX-A (Botox) and nonanimal sourced hyaluronic acid (NASHA, Restylane) in combination compared with NASHA (Restylane) alone in severe glabellar rhytides in adult female subjects: treatment of severe glabellar rhytides with a hyaluronic acid derivative compared with the derivative and BTX-A. Dermatol Surg 2003;29(8):802–9.


