Fighting Gravity: Perspectives on Facial Rejuvenation

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"After age 40, gravity takes over."
—Bumper sticker

We hard-headed realists of the 21st century may have given up the quest for eternal youth, but we haven't yet stopped looking for ways to slow down the clock and maintain at least the appearance of youth, or to restore it once it has slipped away. The principal focus of such rejuvenation efforts is the face—the part of the body that most clearly shows the ravages of time but that is least readily concealed.

Millions of dollars are spent yearly on cosmetics to mask facial wrinkles and irregularities of texture and pigmentation, and millions more on topical moisturizers, conditioners, vitamins, hormones, and antioxidants (not to mention emu oil) to arrest or reverse the signs of aging. More potent agents are available on prescription or for use by physicians.

Plastic surgery, a specialty that began with efforts to correct congenital deformities such as harelip and to improve appearance and function after burns and other severe trauma, has evolved during the past two generations into cosmetic or aesthetic surgery. Nose jobs, breast augmentations or reductions, tummy tucks and apronectomies, liposuction and body sculpturing, and other techniques for improving on Nature or shedding excess weight fast have increased steadily in popularity.

Besides elaborate, invasive facelifts to correct sagging brows, cheeks, and jowls, plastic surgeons can now offer a number of less drastic, less expensive, and less painful ways of reversing some of the facial signs of aging. Statistics show that people are having these procedures at younger ages nowadays and that an increasing proportion of men are opting to undergo them. Cosmetic medical and surgical procedures are being sought not only by entertainers, politicians, and other public figures, but also by the upper classes of the general public who can afford hefty fees not covered by health insurance or Medicare.

According to the American Society for Aesthetic Plastic Surgery, the number of cosmetic procedures carried out in the U.S. increased 44% from 2003 to 2004. The top five surgical procedures in 2004 were liposuction, breast augmentation, eyelid surgery, rhinoplasty, and facelifts.

Several social factors (abetted by human vanity and the universal appeal of youth and beauty) account for the rising popularity of facial cosmetic surgery. Health insurers now generally decline to pay the higher fees charged by dermatologists for the diagnosis and treatment of acne, atopic dermatitis, warts, and other skin disorders that are within the competence of primary care physicians. This has driven many dermatologists to branch out into the collateral field of aesthetic surgery, performing electrolysis of superfluous facial hair, cryoablation or laser treatment of blemishes, and minor plastic procedures.

This encroachment of dermatologists on the turf of board-certified plastic surgeons has led to a contest to see which specialty can afford more advertising on billboards and TV and in the Yellow Pages. One such practice in California spends $35,000 a month on "promotion." Obviously the old adage is no less true in purveying medical services than in selling groceries: "Advertising doesn't cost; it pays."

Some of the increase in the demand for facial cosmetic surgery no doubt stems from media exposure on television shows such as "Extreme Makeover." These programs exploit the sensational contrast between "before" and "after" images, but don't inform viewers that the impressiveness of the results has been enhanced by artistically planned and applied makeup and hair-styling.

And by compressing each patient's surgical odyssey into less than one hour of air time, they downplay the realities. These procedures must be carried out in many separate stages over a period of months and typically involve chiselling and grafting of facial bones and cartilages, elaborate dental work (frequently prosthetic replacement of most or all natural teeth), implantation of synthetic materials, intensive physical and speech therapy, protracted seclusion from social contacts, prolonged uncertainty about the results, and lots of pain. It need scarcely be added that patients whose makeovers yield unsatisfactory outcomes because of severed facial nerves, hypertrophic or pigmented scars, dimpling, contractures, persistent swelling, or maladroit or asymmetrical recontouring will never appear on your TV screen.

This article surveys newer and less drastic chemical and surgical procedures for facial rejuvenation. Although some of these procedures are also effective against abnormal pigmentation, keratoses, dilated blood vessels, benign and malignant neoplasms, and scars due to trauma, acne, or chickenpox, the main focus here is on the diagnosis and treatment of purely mechanical effects of aging—sagging, wrinkling, and furrowing.

This breakdown of the topic is somewhat artificial, because these three types of skin change can occur together in an infinite variety of combinations, and their causes overlap and interact. Temporal changes such as the gradual atrophy of

subcutaneous fat, chemical degradation or loss of collagen and elastin fibers from the dermis, and loss of water from the epidermis are some of the more prevalent and predictable causes of skin deterioration due to aging.

But other factors, particularly heredity, ultraviolet radiation from the sun and other sources, and exposure to environmental toxins such as cigarette smoke, also play a major part in much of the skin change attributed to aging. Sagging and drooping reflect the influence of gravity on tissues that have lost their elasticity and tone. Obesity (superfluous subcutaneous fat) accentuates sagging and remodeling of contours. Facial furrows or creases result from repetitive or habitual contraction of the muscles of facial expression.

Sagging or ptosis refers to a gradual downward displacement of lax tissues by sustained exposure to the force of gravity. Common sites of ptosis in the face are the forehead, eyelids, and jowls.

Sagging of the forehead allows the eyebrows to droop over the eyelids, creating a groggy or morose appearance. Ptosis of the upper eyelids, even when not augmented by sagging of the brows, can be so severe as to block the line of vision. Drooping lower eyelids can become everted, exposing the conjunctiva (ectropion) and permitting spillage of normal tears (epiphora). Atrophy of subcutaneous tissue around and beneath the eyes can give them a hollow look or create a prominent groove beside the nose (tear-trough deformity) or dark crescents or "bags" below the eyes.

The word *jowl* can mean either the normal jaw and cheek area or a fleshy prominence of the lower cheek. Jowls in the latter sense are bilateral folds of sagging skin that accentuate the normal commissural creases at the sides of the mouth, particularly in persons with excess subcutaneous fat. These vertical lines extending downward from the corners of the mouth to the sides of the chin are sometimes called marionette lines because they correspond to the edges of the movable jaw in a puppet or ventriloquist's dummy.

Other examples of facial sagging are the double chin, the witch's chin, pendulous earlobes, and a fold of lax skin at the front of the neck resembling the dewlap of an ox or the wattle of a fowl.

Wrinkles (rhytides) are fine lines, actually superficial creases or furrows in the epidermis, that result from changes in the microscopic structure and biochemistry of the dermis and from diminished hydration of the epidermis. Depending on their location, wrinkles may form elaborate networks of criss-crossing lines. Stretching the skin manually or altering skin tension by changing facial expression may abolish wrinkles temporarily. Although associated with aging, wrinkling is chiefly caused by sun damage and exposure to environmental toxins such as tobacco smoke.

Facial wrinkling is apt to be particularly prominent around the eyes and mouth. The Fitzpatrick classification measures the degree of wrinkling in those two areas:

Class I: Fine wrinkles.

Class II: Fine to moderately deep wrinkles and a moderate number of lines.

Influenced by popular demand, plastic surgeons . . . adapted techniques and materials that had originally been developed to revise disfiguring scars, replace missing noses, and rebuild shattered jaws in order to reduce, augment, or remodel normal features, particularly facial ones, that failed to match patients' ideal self-images. Thus was the specialty of cosmetic and aesthetic surgery born.

Class III: Fine to deep wrinkles, numerous lines, and possibly redundant folds.

Furrows or grooves are skin creases that are deeper than wrinkles and that are less readily abolished by changes in skin tension. In general, furrows result from decades of repetitive or habitual stresses and strains placed on the skin by underlying muscles, particularly the muscles of facial expression. In early life, furrows come and go with changes in muscle contraction and tone. With the passage of time and loss of elasticity in the dermis, furrows become static or fixed.

The following are the more familiar types of facial furrows:

Crow's feet (furrows radiating laterally from the outer corners of the eyes) are due to smiling and other activities that cause contraction of the orbicularis oculi and other eyelid muscles.

Worry lines (parallel horizontal furrows, wavy but bilaterally symmetrical, between the hairline and the eyebrows) result from prolonged or repetitive contraction of the frontalis muscle. Tightening of this muscle is a typical response to emotional stress and a key element in the genesis of muscle tension headache. The normal function of the frontalis muscle is to elevate the eyebrows and, to a lesser extent, the upper eyelids. This action may become increasingly habitual for persons with sagging brows and lids.

Frown lines (short vertical furrows between the eyebrows) are due to contraction of the corrugator supercilii muscles and the procerus muscle, actions that often accompany anger or intense mental concentration.

Smile lines (exaggerated nasolabial folds, the creases that run from the sides of the nose to the corners of the mouth).

Whistle lines or *smoker's lines* (furrows radiating outward around the mouth) result from the puckering action of the orbicularis oris muscle.

The net effect of all this facial drooping, wrinkling, and creasing is to make the owner of the face look tired, distraught, forlorn, or just plain old. These changes in our appearance affect not only the way others perceive us and react to us but also (unless we've thrown away all our mirrors) the way we perceive and feel about ourselves. That has provided a powerful incentive for the medical profession to develop means of

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correcting or improving the dermatologic ravages of aging, particularly on the face.

Resurfacing is a general term referring to techniques in which the superficial layers of the epidermis are peeled off by chemical or mechanical means. Various forms of resurfacing can satisfactorily reduce wrinkling, acne scarring, irregular pigmentation, and coarsening of the skin. Unless combined with other methods, resurfacing has no effect on sagging or on static furrows.

Retinoids are derivatives of vitamin A (retinol), whose effects include maintenance of normal epithelial function. Retinol and its derivatives have been widely used in the treatment of acne vulgaris and, more recently, for wrinkling of the face, neck, and hands. Retinoids used in dermatology are believed to exert their effects by modulating the proliferation and differentiation of epidermal cells, increasing the turnover rate of cornified squamous epithelium, and promoting the shedding of superficial cornified cells.

Vitamin A can be obtained without a prescription in both oral and topical forms, but its effectiveness in acne falls far short of that of its more powerful prescription derivatives such as topical tretinoin (Retin-A) and adapalene (Differin) and oral isotretinoin (Accutane). Besides being an effective treatment for mild to moderately severe acne, tretinoin has also been shown to reverse some of the changes due to the combined effects of aging and ultraviolet radiation: wrinkles, freckles, and solar keratoses.

Although generally well tolerated, tretinoin creams or gels typically cause mild drying, erythema, and peeling of treated areas, particularly at the start of therapy. They may also sensitize the skin to sunlight. Their principal advantages are that they can be applied by the patient, with adjustment of dosage as appropriate from day to day, and seldom cause enough visible effects to require absence from work or avoidance of social contacts.

One direct effect of aging on the skin is a delay in the shedding of superficial squamous epithelial cells. The gradual accumulation of these cells on surfaces not regularly exposed to friction, such as the face, can give the skin a dull, rough, dry, or dusty look. A **chemical peel** is a dermatologic procedure consisting of the application of one or more chemicals to facial skin in order to detach superficial cells. It may also be employed to treat wrinkling and other forms of aging and sun damage.

The expected result of a peel is a fresher-looking, smoother, more evenly pigmented skin surface. Depending on the agent or agents used and the length of exposure, a variable number of layers of epidermal cells are destroyed and removed. Superficial peels can be performed by cosmeticians, nurses, or physicians' assistants and usually cause only mild erythema and stinging, with no need to spend a recovery period at home. But they may need to be repeated at intervals as short as one or two weeks in order to maintain a healthier appearance of the skin. More aggressive procedures, performed by dermatologists or plastic surgeons, are more painful and produce edema, erythema, and crusting that may last for more than a week. These deeper peels are repeated only at intervals of several months to one year.

Chemical peels tend to have cumulative benefits. With repeated applications at higher concentrations, even milder agents may gradually retexture the skin as dermal collagen and elastin regenerate. Continued treatments also reportedly help to stabilize oily or acne-prone skin and improve skin tone. Although fine wrinkles and some acne scars are less obvious after peeling, this technique has no effect on deep furrows.

Glycolic acid (alpha-hydroxyacetic acid) is a relatively mild peeling agent that, when used correctly, produces only slight stinging and erythema. The usual procedure is to cleanse the face thoroughly, apply a 20-70% solution for three minutes, then neutralize the acid chemically and flush it away with water. Lower strength solutions are used for initial treatments, and the strength is adjusted in proportion to the response. Glycolic acid is present at very low concentrations in some topical skin conditioners and moisturizers. Citric and lactic acids are other alpha-hydroxy acids that may be used as mild peeling agents.

For deeper peeling, a more corrosive agent such as **trichloracetic acid** (TCA) in a concentration of 20-35% may be chosen. The effectiveness of this chemical in dissolving keratin (the chief protein of epidermal cells) is well known from its long use in treating warts and other keratoses. TCA peels are painful and for a few days the patient may look like a survivor from a nuclear blast. With healing there is usually an impressive improvement in skin texture, with reduction in wrinkles, blotchy pigmentation, freckling, and solar keratoses.

Extremely deep peels with powerful agents such as phenol (carbolic acid) are seldom performed nowadays because of the risk of systemic toxicity, scarring, and other cosmetically unacceptable results such as a waxy, masklike appearance of the skin.

Peeling protocols may include topical hydroquinone to lighten pigment spots, tretinoin to accelerate maturation and shedding of superficial cells, sunscreen to protect freshly treated skin from ultraviolet damage, and topical or systemic antivirals and antibiotics.

Dermabrasion is a mechanical rather than a chemical resurfacing technique that was developed about 100 years ago in Germany to treat facial scars due to acne. Nowadays is it also used to erase wrinkles, pigmented birthmarks, tattoos, and keloids and to treat rosacea, rhinophyma, and some skin neoplasms. In this procedure the surgeon grinds away and reshapes the skin surface by means of a selection of sanding cones, wire brushes, and fraises (spiked wheels) driven by a hand-held high-speed rotary power tool.

For treatment of small areas, local anesthesia combined with sedation may be adequate, but general anesthesia is routine when the entire face is to be treated. After the target area has been scrubbed with antibacterial soap, it may be chilled with ice packs or a freezing spray to provide a firmer surface and enhance anesthesia. Adjunctive treatment may include administration of tretinoin for several days before and after the abrasion procedure and a prophylactic antiviral such as acyclovir to prevent herpes simplex, a frequent complication.

Dermabrasion can often yield highly satisfactory and long-lasting improvement in the appearance of aging skin. However, the procedure itself results in a painful injury with intense erythema, swelling, oozing of blood and serum, and crusting. Complete healing may take several months. Possible complications are infection, scarring, and abnormal pigmentation of treated areas.

Microdermabrasion is an alternative method of removing surface skin cells mechanically without recourse to tools that might have come from a sculptor's studio or a cabinetmaker's shop. This technique, which employs a blast of fine, sterile grit such as aluminum oxide or ice crystals as the abrasive, takes only a few minutes and requires no anesthesia. Its effects are approximately those of a superficial chemical peel. It can effectively remove wrinkles and other fine surface irregularities, but 10 to 20 treatments may be needed before a satisfactory result is achieved.

Laser resurfacing is yet another method of removing the top layers of the epidermis so as to lessen or abolish wrinkles, acne scars, pigmented nevi, tattoos, and other superficial lesions. Performed with a YAG or CO_2 laser, this procedure allows highly precise surface contouring, as in the similar technique of corneal reshaping, and is particularly effective for wrinkles around the eyes and lips. Local or general anesthesia may be used. Laser resurfacing, like methods involving chemical corrosives or mechanical abrasives, results in some swelling, oozing, and crusting. Erythema and heightened sensitivity to sunlight may persist for several weeks. Undesirable irregularities of pigmentation occur in some patients, particularly those with darker skin.

Thermage (rhymes with *garage*; also called nonablative resurfacing, thermal resurfacing, or radiothermoplasty) uses radiofrequency energy to raise the temperature of the dermis. This tightens deteriorated collagen fibers and stimulates formation of new collagen during succeeding weeks and months, thus correcting superficial lines and wrinkles. The procedure has also produced improvement in some cases of moderate to severe acne, evidently by a different mechanism.

Areas to be treated are carefully mapped in advance and identified by a grid placed over the face at the time of treatment. After application of a topical anesthetic and a coupling fluid that serves as a conductive medium for RF energy, the treatment tip is brought into contact with the skin while a cooling spray bathes the site continuously to prevent burning of the skin surface. During the treatment session, which takes 1-2 hours, the energy input can be lowered if necessary to prevent the sensation of warmth from reaching the pain level.

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The procedure typically produces redness and swelling that persist for hours to days. As a general rule the eventual benefits of treatment are in proportion to the amount of initial redness and swelling. Thermal resurfacing yields the most satisfactory results in mild laxity, wrinkling, and creasing around the nose and mouth. Full results may take many months, and only about 25% of patients ever show clear-cut improvement. This technique carries a small risk of surface burns with blistering and scarring. Some patients develop dimpling due to fat atrophy.

George Washington's face was so badly scarred by smallpox that, while sitting for the portrait by Gilbert Stuart that is reproduced on the one-dollar bill, he held masses of cotton in his mouth (in addition to the famous false teeth) to restore the normal contours of his cheeks. **Facial augmentation** is a general term for any procedure in which a material is injected or implanted below the surface to fill in hollows, pits, creases, and other volume defects.

Originally developed to correct severe scarring and deformity, facial augmentation has become a popular adjunct to aesthetic facial surgery, partly because most such procedures are minimally invasive and require little or no recovery time. Volume restoration is particularly effective in smoothing out crow's feet, whistle lines, acne pits, and other scars. It may also be used to fill out hollow cheeks or to impart fullness to the lips and chin.

The ideal implant material would be biocompatible, nonallergenic, chemically and physically stable, nonbiodegradable, and easily introduced by injection through a needle. Of the broad variety of substances and materials currently available for facial augmentation, none meets all those criteria and none is suitable for all applications.

Facial fat grafting is a variant of liposculpture in which superfluous fat cells are removed from the patient's own abdomen or thighs and injected into the subcutaneous tissues of the face to fill in surface defects or augment certain areas for aesthetic reasons. Under local anesthesia, subcutaneous fat is aspirated from the donor site through a small incision with a large-bore cannula. After extraction of blood and connective tissue fibers, the fat is injected under facial skin and the surface contours are remodeled by manipulation. The procedure usually causes short-lived edema and ecchymosis. Icepacks may be applied for the first 2-3 days.

The popularity in the U.S. of the nonsurgical facelift, variously known as ThreadLift, FeatherLift, or "lunchtime facelift," has recently exploded as a result of television exposure.

This is a true autologous free graft. That is, some of the reimplanted fat survives as living tissue in its new location. Unfortunately an unpredictable amount—usually about two-thirds—of the grafted fat is eventually resorbed. The procedure may therefore need to be repeated several times before adequate results are obtained. If more fat is injected than the local blood supply can sustain, atrophy of grafted material can lead to lumpiness. The great advantage of fat grafting is that allergic reactions and immunologic rejection cannot occur with the patient's own tissue.

Collagen (from Greek *kolla* 'glue') is a generic term for a group of fibrous extracellular proteins that bind, support, protect, and cushion other structures throughout the body while also providing a degree of flexibility and elasticity. Collagen is the principal component of connective tissue fibers in the dermis, tendons, ligaments, tendon and muscle sheaths, bones, and other tissues.

Degradation and disappearance of collagen are major causes of dermal atrophy associated with both aging and sun exposure. Injections of collagen are used not only to fill in sagging, hollow areas of the face but also to smooth out wrinkles, creases, and depressed scars. Collagen used for this purpose may be obtained from bovine or porcine skin or from cultures of human skin cells. It can also be obtained by culturing the patient's own tissues, including fibroblasts, the cells that make collagen.

A saline suspension of purified collagen mixed with local anesthetic is injected into the dermis with a fine-gauge needle and the implanted material is distributed as needed by massage. The procedure is well-tolerated and necessary aftercare is minimal. Because of the substantial risk of allergic reaction, implantation of nonhuman collagen must be preceded by skin-testing. Implanted collagen is gradually degraded and absorbed. The procedure may therefore need to be repeated at intervals of 6-24 months. CosmoDerm, CosmoPlast, Zyderm, and Zyplast are commercially available formulations of collagen used in facial augmentation.

Another component of connective tissue that can be injected for facial augmentation is **hyaluronic acid**. This high molecular weight polysaccharide with a viscous, jelly-like consistency is a normal constituent of joint fluid, the vitreous humor, cartilage, the dermis, and the umbilical cord. In the dermis it serves as a cushioning and lubricating agent, a means of maintaining normal skin hydration, and a transport medium for nutrients from the circulation to skin cells.

Aging and ultraviolet exposure lead to gradual depletion of hyaluronic acid in the dermis. Preparations of natural or synthetic hyaluronic acid can be used to elevate skin depressions and improve or abolish wrinkling and creasing in all areas of the face. Under local anesthesia, the filler material is placed in the dermis either by a series of small injections or by retrograde deposition, that is, by continuous injection from a long needle as it is gradually withdrawn after having been threaded through the treatment area.

Local redness and swelling resulting from the treatment last only a day or two. Allergy is rare and skin testing is not considered necessary. More than one treatment session may be necessary to achieve adequate filling of defects. Because injected hyaluronic acid is absorbed fairly rapidly, cosmetic improvements persist for only 6-9 months. Hylaform, Perlane, and Restylane are brands of hyaluronic acid used as facial fillers.

Unlike fat, collagen, and hyaluronic acid, some injectable or implantable facial fillers are entirely foreign to human body chemistry. **Polymethylmethacrylate** (PMMA) is a synthetic resin, familiar to most of us as Plexi-Glas, that is also used to make hard contact lenses and to repair bone and tissue defects. For facial augmentation it is injected in the form of microscopic beads (microspheres) suspended in collagen, hyaluronic acid, or another suitable vehicle. The injected material is redistributed by manipulation until wrinkles, creases, scars, and other defects are satisfactorily filled in.

The procedure is well tolerated and local inflammation subsides quickly. Although the suspending medium is eventually absorbed, the synthetic resin remains in position. As it gradually becomes encapsulated by dermal connective tissue, it forms a firm, permanent implant. Allergy to the resin is rare, but skin testing is necessary if the resin is suspended in nonhuman collagen. Artecoll, Arteplast, and Metacrill are cosmetic formulation of PMMA microspheres suspended in various media.

Polyacrylamides are a class of synthetic polymers with numerous biomedical applications. Because they are chemically and biologically inert and nonallergenic, these materials are used in the manufacture of cosmetics and skin care products, soft contact lenses, and a wide variety of surgical implants, as well as in instruments and products for clinical laboratory procedures.

Hydrophilic polyacrylamide gel (HPG) is an aqueous suspension of 2.5 to 5% polyacrylamide that is used as a filling agent for facial lines, creases, scars, and other volume deficits. Injected into subcutaneous tissue by a retrograde technique, the suspension is molded to the desired shape by massage. The water is quickly absorbed, leaving the suspended polyacrylamide behind as a permanent filler that, like PMMA, eventually becomes encapsulated by connective tissue. Unlike PMMA, injected polyacrylamide remains soft and pliable. For that reason its position may gradually shift, with loss of earlier cosmetic benefits. Rarely, polyacrylamide causes local granuloma formation.

The term **implant** refers to a solid object (that is, something with a fixed three-dimensional shape) that is placed surgically within living tissue to fill a defect, correct a deformity, or otherwise improve the texture, rigidity, shape, or function of a part. Various nontoxic and nonallergenic materials have

found broad application in the manufacture of implantable prostheses for the surgical specialties.

Implants are used for facial augmentation when injectable materials cannot provide sufficient bulk, firmness, or permanency. The same general procedure is used for all solid implants, regardless of chemical composition. After preparation of the skin surface and administration of local anesthetic, the surgeon makes a small incision and, by blunt dissection, creates a pouch or tunnel for the reception of the implant. The sterile implant material, carved or trimmed to the desired shape, is then positioned and secured in the pouch and the skin incision is closed.

Fine points of technique vary with the part of the face involved, the product used, and the type of augmentation required. Postoperatively some transitory local inflammation is usual. Severe adverse effects such as infection, foreign body reaction with excessive fibrosis, and shifting or extrusion of the implant are rare. Implant materials that have a porous or meshlike microstructure allow for the ingrowth of blood vessels and connective tissue fibers. This stabilizes the implant mechanically and enhances its integration into surrounding tissues. Implants of synthetic materials are intended to be permanent. They can, however, be surgically repositioned if necessary, or removed in the event of infection or other untoward consequences.

The physical and chemical properties of **polytetrafluoroethylene** (PTFE), more familiarly known under its trade name Teflon, make it an ideal material for countless industrial and biomedical applications, including implants in orthopedic and cardiovascular surgery. Expanded polytetrafluoroethylene (ePTFE, Gore-Tex) consists of fibrils of this polymer that have been woven into a meshlike fabric. Strong and waterproof, it is used in the manufacture of outdoor garments and surgical gowns and drapes as well as vascular and orthopedic grafts and implants for facial augmentation. The porous structure of ePTFE allows ingrowth of blood vessels and connective tissue fibers, but only to a limited extent. Implants of this material must be placed deep in the subcutaneous tissue layer to avoid unduly severe inflammatory reactions.

High-density **polyethylene** (HDPE) is another synthetic polymer used in fashioning implants for facial augmentation. As the brand name Medpor suggests, the dimensions of its pores makes it highly suitable for vascular and connective tissue ingrowth. Prolene and Marlex are mesh forms of HDPE.

Hydroxyapatite, an inorganic compound of calcium and phosphorus, is the chief mineral constituent of bones and teeth. Implants of hydroxyapatite derived from sea coral have been found suitable for plastic surgical procedures including facial augmentation. This material is sufficiently porous to allow ingrowth from surrounding tissue. Eventually, implanted hydroxyapatite is partially absorbed and replaced by natural bone.

Solid silicone (dimethylsiloxane) is a durable, flexible synthetic polymer with a long history of satisfactory use in heart valve replacements, joint prostheses, and facial augmentation. Unlike the liquid silicone used in breast implants, solid silicone implants do not leach or diffuse into surrounding tissues, and cause relatively little foreign body reaction. Silicone implants for facial augmentation are manufactured in varying degrees of hardness. Because they are not porous, they do not become integrated into surrounding tissues.

. . . nonsurgical treatments such as botulinum toxin injections and minimally invasive procedures such as chemical peels and injections of fillers have become increasingly popular because they involve much less pain, healing time, and expense.

According to the American Society for Aesthetic Plastic Surgery, in 2004 the most popular nonsurgical cosmetic procedure was injection of **botulinum toxin**. More than 1.8 million injections were administered in the U.S., an increase of 25% from 2003.

Botulinum toxin is often described as the most potent poison, or the most toxic substance, known to science. One gram of purified toxin (roughly the weight of a paperclip) could kill about a million people; six kilograms (roughly the weight of a bowling ball) could kill every man, woman, and child on this planet. What is something that deadly doing in the armamentarium of the dermatologist and cosmetic surgeon?

Clostridium botulinum is a spore-forming anaerobic bacterium that causes a potentially lethal type of food poisoning called botulism. This organism is particularly likely to flourish in canned vegetables, smoked or potted meats, dried or vacuum-packed fish, and sausage. Like closely related species that cause tetanus, gas gangrene, and pseudomembranous enterocolitis, *Cl. botulinum* produces its effects by elaborating a toxin—actually a group of chemically similar neurotoxins. Proliferation of organisms within the patient does not occur except in infants (who may acquire infection from organisms present in honey) and in a non-food-related variant, wound botulism.

Botulinum toxins absorbed from the digestive tract and carried throughout the body in the circulation block neuromuscular conduction by binding to motor nerve terminals and inhibiting the release of acetylcholine. The classical presenting symptoms of botulism, occurring 12-36 hours after ingestion of toxin, are six D's: diplopia (double vision due to paralysis of extraocular muscles), dilatation of the pupils, drooping of the eyelids, dysphonia (hoarseness due to vocal cord paralysis), dry mouth, and dysphagia (difficulty swallowing). Progressive weakness and paralysis of skeletal muscle, including respiratory muscles, may follow. Some patients experience nausea and vomiting. Treatment is by administration of antitoxin, endotracheal intubation and mechanical ventilation, parenteral nutrition, and other supportive measures. With timely diagnosis and treatment the prognosis is excellent.

Botulinum toxin was first used therapeutically in 1980 to treat strabismus. A minute quantity of purified toxin (type A)

injected into an overactive extraocular muscle was found to paralyze the muscle, permitting coordination of gaze and binocular vision without diplopia. Use of the toxin was first approved by the U.S. Food and Drug Administration (FDA) in 1989 for strabismus and blepharospasm. This led to the observation that some middle-aged patients treated with injections of botulinum toxin for these disorders experienced a smoothing of glabellar frown lines, thus appearing more cheerful, more relaxed, and . . . younger!

Placebo-controlled studies subsequently showed that injection of toxin directly into the right and left corrugator supercilii muscles and the midline procerus muscle usually produces a striking improvement in moderate to severe glabellar furrows within one week. Because the chemical denervation of muscle by toxin is temporary, treatments must be repeated at intervals of a few months in order to maintain the response.

On April 15, 2002, the FDA announced its approval of a cosmetic formulation of botulinum toxin for the temporary improvement of glabellar frown lines. Botulinum toxin for this indication is marketed as Botox Cosmetic by Allergan. Each vial contains 100 units of purified, vacuum-dried type A toxin. After reconstitution with sterile physiologic sodium chloride solution, each 0.1 mL (the recommended volume of a single injection) contains 4 U of toxin. The standard protocol for treatment of glabellar furrows calls for one injection into the procerus muscle and two injections into each corrugator supercilii muscle for a total dose per session of 20 U. Injections are made with a 30-gauge needle.

Treatment may be followed by local pain, tenderness, and ecchymosis lasting 2-3 days or longer. Some patients experience ptosis of one or both eyelids if toxin reaches one or both levator palpebrae superioris muscles. The risk of this can be reduced by careful injection technique. Like the therapeutic effect of the injection, lid ptosis resolves with time. Systemic toxicity has not been reported. Botulinum toxin is contraindicated during pregnancy and lactation, in persons with certain neuromuscular disorders, and in those who have had adverse reactions to previous doses. Diminishing response has been observed in some patients who have formed a neutralizing antibody to the toxin. The likelihood of antibody formation is greater when high doses are administered at short intervals.

Repeated injections of toxin may eventually induce atrophy of treated muscles, with enhanced and more lasting effects. However, some observers believe that chemically denervated muscles can develop new acetylcholine receptors and that treated patients can develop new ways of frowning and hence new furrows.

In view of its mechanism of action, it isn't surprising that botulinum toxin is ineffective against static furrows and wrinkles caused by sun damage or dermal atrophy. That hasn't prevented its extensive use for such off-label indications as worry lines, crow's feet, sagging cheeks and jowls, and redundant neck folds.

The phrase *plastic surgery* has nothing to do with the numerous synthetic materials, usually lumped together as "plastics," that virtually redefined human culture during the 20th century by extensively replacing wood, metal, cloth, rubber, and other natural products. These substances are called plastic because they can be formed, molded, or shaped (Greek *plastikos*). Just as sculpture is called a plastic art, surgery whose purpose is to model or remodel parts of the human body is called plastic surgery.

The origins of this branch of surgery are buried in remote antiquity. Reconstruction after facial injuries was practiced as early as 2000 BC. The Indian surgeon Susruta, who is believed to have lived around 800 BC, performed rhinoplasty and sliding, rotational, and pedicle grafts. Techniques for cleft palate repair were developed long before the era of surgical anesthesia and asepsis.

Throughout human history, a principal impetus for progress in plastic and reconstructive surgery has been war. As increasingly powerful and destructive weapons have been developed, military surgeons have had to deal with increasingly extensive and mutilating battle wounds. Thanks to advances in emergency medicine, victims of severe multiple trauma who once would have died on the battlefield now survive and return to civilian life with deformities and disabilities of staggering proportions.

Modern plastic surgery came into its own as it struggled to deal with extensive facial and head injuries, burns, and loss of limbs in the aftermath of World War I. Pioneer work in this field on both sides of the Atlantic achieved results that seemed little short of miraculous. The public imagination, helped along by journalists and writers of sensational fiction, translated these biotechnical advances into a whole new form of supersurgery that could alter the shape of the human face at will, changing the identity of the subject or, more fantastically still, duplicating the face of someone else (see box).

Suggestions for Collateral Reading

Carr, John Dickson: *It Walks by Night*
Freeman, R. Austin: *For the Defense: Dr. Thorndyke*
Goodis, David: *Shoot the Piano Player* (source of the Bogart-Bacall film *Dark Passage*)
Kesselring, Joseph: *Arsenic and Old Lace* (play and Cary Grant-Peter Lorre film version)
Leroux, Gaston: *Chéri-Bibi* (and its sequels)
Oppenheim, E. Phillips: *The Great Impersonation* (filmed under the same title)

Influenced by popular demand, plastic surgeons quickly adapted techniques and materials that had originally been developed to revise disfiguring scars, replace missing noses, and rebuild shattered jaws in order to reduce, augment, or remodel normal features, particularly facial ones, that failed to match patients' ideal self-images. Thus was the specialty of cosmetic and aesthetic surgery born. The field quickly advanced from rhinoplasties and chin augmentations to facelifts, breast aug-

mentations and reductions, liposuction, and body sculpturing. Many of the subsequent developments in the field of plastic surgery—notably silicone-filled breast implants—were driven by purely aesthetic considerations.

Mitigating or reversing the signs of aging in the face and neck has always constituted a major part of cosmetic surgery. For several decades the facelift or rhytidectomy was the cosmetic surgeon's bread and butter. (Although *rhytidectomy* translates as 'cutting out wrinkles', the procedure actually consists in cutting out fat and tightening facial muscles and overlying redundant skin.) Fees for a full facelift, which are not covered by health insurance or Medicare, can easily reach $20,000 when hospital, operating room, and anesthesiologists' fees are factored in.

As mentioned earlier, nonsurgical treatments such as botulinum toxin injections and minimally invasive procedures such as chemical peels and injections of fillers have become increasingly popular because they involve much less pain, healing time, and expense. For the same reasons, the aging public has enthusiastically embraced a type of minimally invasive facelift procedure devised within the past decade.

For many years plastic surgeons have tried to perform brow, cheek, jowl, and neck lifts without incisions by suspending sagging tissues with nonabsorbable suture materials threaded through various tissue layers of the face. Results have been generally unsatisfactory because of technical difficulties of suture placement and the gradual loss of support as suture materials cut through tissues.

In the early 1990s, the U.S. plastic surgeon Gregory Ruff invented a nonsurgical facial rejuvenation procedure that involves the subcutaneous placement of lengths of monofilament polypropylene suture material in which evenly spaced barbs or cogs have been fashioned to catch and hold tissue. This material, developed by Quill Medical as Contour Thread, received FDA approval in 2004. A similar product, invented by Marlen and Georges Sulamanidze of Russia and manufactured in this country by K.M.I. (Kolster Methods, Inc.), is known by the trademark Aptos (based on the coined term *aptosis*, meaning 'without drooping') and by the colloquialism "Russian threads." As of this writing, Aptos threads have not been approved by the FDA.

The popularity in the U.S. of the nonsurgical facelift, variously known as ThreadLift, FeatherLift, or "lunchtime facelift," has recently exploded as a result of television exposure.

Like many revolutionary inventions, this one is the essence of simplicity. The barbs or spurs on each half of a strand point toward the center. A strand measuring 5-18 cm in length is inserted by means of a large-bore hollow needle that is carefully positioned in the subcutaneous fat layer and then withdrawn, leaving each end of the strand protruding from the skin. With gradual tightening of the strand combined with surface manipulation, the barbs engage the tissues, lifting the sagging brow, cheek, jowl, or neck until the desired correction is obtained. Because the procedure normally requires only local anesthesia, the patient can provide immediate feedback to the surgeon as to the degree of tightening required.

Once a strand has been satisfactorily positioned, each end is trimmed flush with the skin surface. As many as 20 strands may be inserted in parallel or crisscross patterns at one session. The expected swelling and ecchymosis usually last only 1-3 days, and most patients can return to work within that period. Complications such as infection and scarring are rare. Removal of threads, if needed, is relatively simple.

Within a few weeks, superfluous skin over treated areas tightens. Later, collagen deposition around threads tends to smooth out surface contours. Maximal improvement may take several months. Because the thread lift procedure cannot match the results of a surgical facelift, it is most suitable for middle-aged persons who are showing early signs of aging. Additional threads can be added later if needed. For optimum benefit it may need to be combined with other surgical or nonsurgical techniques. Depending on the number of threads placed, the cost of the procedure varies from $2000 to $8000.

The adage that prevention is far superior to cure applies to skin care as well as to other facets of physical health and well-being. Facial rejuvenation procedures, no matter how ingenious and successful, can't really turn back the clock or fully reverse the effects of aging. More to the point, many of the changes that occur in facial skin with the passage of the years are due not so much to aging as to ultraviolet exposure (including artificial tanning) and cigarette smoking.

To stave off that first visit to the aesthetic surgeon, use a good sun blocker (SPF 30 or higher), don't smoke, avoid second-hand smoke, and apply moisturizers to improve the texture and water-holding capacity of your skin. *Gravitas* is Latin for 'weight'. One way to limit the effects of gravity on lax facial tissues would be to spend half your waking hours hanging upside-down. A more practicable way is to maintain a healthful weight.

Please don't stop smiling in order to avoid developing crow's feet. Just rename them "wisdom lines."

Web Sites with Illustrations of Cosmetic Surgery

http://www.amazingfaces.com/contour_thread_lift.html
http://www.prollenium.com/aesthetic001.html
http://store.nutecint.com/index.asp?PageAction=VIEWPROD&ProdID=116http://store
http://nutecint.com/index.asp?PageAction=VIEWPROD&ProdID=4

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