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Reconstruction Topics

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MORPHOGENESIS OF WRINKLES
Wrinkling of the skin is largely the result of aging, actinic damage, or genetic disorders acting singly or in combination with one another.

Normal Aging
Aging of the skin is a process of atrophy. In the epidermis, the stratum corneum changes very little in thickness despite loss of the dermoepidermal papillae. A gradual reduction in the melanocyte population occurs, and the number of Langerhans cells that are intimately involved with cell-mediated immunity decreases. The most significant cutaneous changes take place in the dermis, particularly in the upper third. Smith described the histological changes in the aging dermis. He explained that with years of aging, much of the reticular dermis is lost and the overall dermal organization reduced. The total amount of collagen in the dermis decreases with age. The loss of collagen is largely responsible for thinning of skin to as little as 20% compared with the skin of a younger adult.

The three primary components of dermal connective tissue layer—glycosaminoglycan gel, elastic fibers, and collagen—show progressive diminution or disruption. The total amount of ground substance (composed of glycosaminoglycans and proteoglycans) decreases with age. Elastic fibers are composed of at least two distinct proteins: elastin and microfibrillar component. In adults, elastic fibers occupy 2% to 4% of the total volume of the dermis. The apparent role of elastic fibers is to maintain the waving of the collagen bundles; disruption of the elastic fibers results in loss of the physiological recoil and laxity of the skin. With the aging process, the finer oxytalan fibers that normally extend perpendicularly through the papillary dermis and into the epidermis are depleted or absent. Because so much collagen is lost, the elastic component can seem to be increased in older skin. These intrinsic degenerative changes begin at approximately age 30 years.

The predominant tissue component of normal human dermis is collagen, which comprises 70% to 80% of dermal dry weight. Normal adult human skin contains type I and type III collagen in an approximate 6:1 ratio. With age, the ratio becomes smaller as the proportion of type III collagen increases, perhaps reflecting impaired synthesis of type I collagen in aged skin. The total dermal thickness decreases with age by an average 6% per decade of life in both men and women.
The collagen aging process varies among animal species. The rodents in which studies are frequently conducted might have a pattern of cross-linking associated with aging that is different from that of humans; even lower forms of primates sometimes show changes that are species-specific. For that reason, conclusions regarding the dermal aging process in man should be based on human study participants.6,10

The skin appendages are also affected by aging. With increasing age, sebaceous glands tend to increase in size, although their number remains relatively constant. Pacinian and Meissner corpuscles—the end-organs responsible for the sensation of pressure and touch—decrease in number as the skin ages. A large body of literature is dedicated to chronicling the deterioration of skin with age.

Of special merit are the review articles by Gilchrest,11,12 Fenske and Lober,3 Uitto,4 Smith,1 Balin and Pratt,7 and others.13 Whitmore and Levine14 explored the relation between decreasing skin thickness and decreasing bone density with age. Unlike a man’s skin, a woman’s skin remains constant in thickness until her 40s, when it is affected by the hormonal changes of menopause. The elasticity of a woman’s skin also declines with the loss of estrogen after menopause, but it can be restored by administration of hormone replacement therapy.15

Photoaging
Kligman16,17 offers an excellent discussion of photoaging. Actinically damaged skin behaves very differently from normal aging skin that has been protected from the sun. Atrophy of skin components is the hallmark of normal aging, whereas actinically damaged skin is thicker than normal. The most striking characteristic of actinically damaged skin is the presence of thickened, degraded elastic fibers in the dermis.18–21 Histologically, the condition is described as “basophilic degeneration” or “elastosis.” In addition, the proportion of ground substance is greatly increased in photodamaged skin, whereas mature collagen is decreased. Immature type III collagen becomes dominant at the expense of the formerly abundant type I collagen.

Sams22 reviewed the scientific body of work regarding elastosis. The elastotic material seen microscopically appears to be a combination of degraded collagen and increased elastin. The desmosine content of the elastotic material is increased over that of normal skin, suggesting that the elastotic material derives from degenerated elastin rather than from collagen.23 The increased thickness of the elastic fibers is accentuated histologically by the age-related decrease in collagen.7

Browder and Beers24 explained the mechanisms of skin tanning, which takes place in two stages. Immediate pigment darkening that occurs as the result of photooxidation of existing melanin is the brief first stage of the tanning process. It takes place during exposure to ultraviolet radiation. The second stage, which is called delayed tanning, becomes apparent approximately 72 hours after exposure. Delayed tanning is caused by increased synthesis of melanin in the epidermis and increased numbers of melanosomes. With repeated exposure, the number of melanocytes can increase.

Deoxyribonucleic Acid (DNA) Damage, Metalloproteinase, and Elastases
Ultraviolet B radiation (280–315 nm) is responsible for DNA damage in cases of skin cancer, and it was therefor assumed that ultraviolet B was the major factor in actinic degeneration of skin. It is now known that ultraviolet A (315–400 nm) is also responsible for actinic skin damage. Each wavelength causes a different type of injury to the DNA of skin cells. Ultraviolet B and ultraviolet C rays result in direct DNA damage. Short-wavelength ultraviolet A2 (315–340 nm) can also cause direct DNA damage. Ultraviolet A1 (>340 nm) results in indirect damage through intermediary molecules.25
Spencer and Amonette review the biological response to ultraviolet radiation, noting that the energy of photons striking the skin must be absorbed by a chromophore capable of absorbing radiation of that particular wavelength. Chromophores in the skin include DNA, proteins, lipids, and urocanic acid. The effects of ultraviolet B are typically observed in the epidermis and those of ultraviolet A manifest in the dermis.

The mechanism of dermal degradation seems to be the induction by ultraviolet A radiation of three metalloproteinases capable of degrading the dermal collagen matrix. The metalloproteinases are a family of proteolytic enzymes that specifically degrade collagens, elastin, and other proteins in connective tissue and bone. Ultraviolet A also stimulates other enzymes such as cathepsin G and elastolytic enzymes that result in degradation of elastin.

Elastase activity has a direct impact on wrinkle formation. Selective inhibition of dermal elastases markedly decreases wrinkle formation. Ultraviolet-mediated actinic damage also affects keratinocytes and significantly alters the normal biosynthetic functions of the epidermis.

Reactive Oxygen Species
Another route of ultraviolet-induced photoaging is through the generation of reactive oxygen species that deplete and damage nonenzymatic and enzymatic anti-oxygen defense systems in the skin. Examples of reactive oxygen species include the superoxide anion ($O_2^-$) and singlet oxygen ($^1O_2$).

Superoxide radicals have been implicated in ultrastructural damage to skin by ultraviolet radiation. Bissett et al. reported that topical application of scavengers of these oxidant species reduces the skin damage induced by acute doses of ultraviolet radiation. Alpha tocopherol applied topically had some protective effect on the skin through its action as a superoxide scavenging antioxidant. Pugliese presented a comprehensive review of the skin and its antioxidant system.

Diet and Environmental Factors
Among the lifestyle factors modulating the aging skin manifestations are hours of exercise per week; the use of caffeine, tobacco, estrogen replacement therapy, exogenous thyroid replacement (which causes suppression of thyroid stimulating hormone [TSH]), or tanning booths; and lifetime exposure to glucocorticoid therapy.

Caffeine
Of particular interest is the possible adverse effect of caffeine on the aging skin. Ingested daily in concentrations of 10 mcg/mL (the serum level reached after drinking three cups of coffee), caffeine can reduce type I collagen synthesis by as much as 15%.

Smoking
A number of authors have remarked on the prevalence of premature wrinkling, especially in the perioral area, in patients with smoking histories. Smoking contributes directly to elastosis. Yin et al. suggested that tobacco smoke creates reactive oxygen species that mediate alterations in matrix metalloproteinases, which result in a 40% decrease in collagen biosynthesis. One study cited a unique pair of twins with markedly divergent smoking histories but well-matched sun exposure history. The twin with a 52.5 pack-year smoking history showed more severe skin aging than did the nonsmoking twin.

Indoor Tanning
Ultraviolet A absorbed in doses that are 100 to 1000 times greater than doses of ultraviolet B, such as have been recorded during indoor tanning sessions, can trigger DNA breakdown. Dermal elastosis can be expected to occur much sooner in people who patronize tanning booths.

Perceived Age
A large-scale study of twins conducted by Guyuron et al. examined the clinical effects and perceived age differences associated with a
variety of environmental factors. Many of the findings regarding the effects of sun exposure, smoking, hormone replacement, alcohol, and marital status effects on aging were not new. The authors’ quantification, however, of the perceived age difference based on the environmental factor was novel. The authors found that the minimum duration of smoking was 5 years to result in a perceived age difference. Every 10 years of smoking lead to a 2.5-year perceived age difference. An increased body mass index resulted in an older appearance at the younger ages but a younger appearance in the older age groups.

Genetic Disorders
Gilchrest, Beauregard and Gilchrest and Thomas et al. presented a discussion of the various syndromes of premature aging affecting the skin. Listed below are some of the more common dermatological conditions that can present as excessive skin laxity or premature aging.

Pseudoxanthoma Elasticum
In its more common severe form, pseudoxanthoma elasticum (PXE) is inherited as an autosomal recessive trait, although autosomal dominant inheritance has been reported. The disease is characterized by increased collagen degradation and deposits of calcium and fat on the elastic fibers. The entire skin is loose fitting, lax, and extensively infiltrated by degenerated elastic fibers. The skin has a pebbled appearance, with small yellowish papules, extreme laxity, and no elastic rebound. The skin changes are more marked in the axilla, groin, and neck.

In the absence of severe systemic vascular or retinal disease, plastic surgery can be of considerable benefit in PXE. Ng et al. presented a report of a successful rhytidectomy in a patient with PXE. Viljoen et al. reported the results of surgical correction of cutaneous signs of pseudoxanthoma elasticum in nine women. Surgery consisted of excision of redundant skin from the neck, axilla, stomach, and inner thigh. Wound healing in all was slower than usual, keloids developed in two patients, and two others had extrusion of calcium particles through the healing scars. Follow-up for up to 15 years showed only moderate recurrence of the skin manifestations.

Ehlers-Danlos Syndrome
Also known as cutis hyperelastica, Ehlers-Danlos syndrome is a rare disorder characterized by fragile, hyperelastic and easily bruised skin, joint hypermobility, subcutaneous hemorrhages, and aortic aneurysm. The key diagnostic feature is the ability to stretch the skin an inordinate amount (to 15 cm or more); but when released, the skin shrinks back into position without wrinkling. This is in marked contrast to the skin in cutis laxa, which does not recoil. The skin changes tend to be generalized, and healing is uniformly poor. Ehlers-Danlos syndrome is frequently associated with posttraumatic bleeding from increased capillary fragility; hence, rhytidectomy is not recommended.

Inher itance is autosomal dominant except for type II, which is sex-linked. The cause is abnormal molecular cross-linking of collagen: type V lacks lysyl oxidase, and type VI lacks lysyl hydroxylase. The disease is usually diagnosed during early childhood, but the symptoms often decrease in severity with aging.

Cutis Laxa
Cutis laxa is, in many ways, the opposite of Ehlers-Danlos syndrome. The main histopathological finding in cutis laxa is degeneration of the elastic fibers in the dermis. Affected persons
have generalized loose skin in all regions of the body. Unlike the skin in cases of Ehlers-Danlos syndrome, the skin in cases of cutis laxa is inelastic and does not spring back into position after stretching. Hyperextensibility of the joints is absent, and skin healing progresses in a relatively normal manner. The defective elastic tissues present as a coarsely textured, drooping skin all over the body that is evident in the neonatal period. Affected infants frequently have associated aneurysms, pneumothorax, emphysema, congenital heart disease, and hernias.

Inheritance can be autosomal dominant, autosomal recessive, or X-linked. Because of incomplete gene penetrance, the autosomal dominant form of the disorder tends to be less severe than the recessive form and tends to involve only the dermis. Patients who have the X-linked form of cutis laxa manifest lysyl oxidase deficiency.

Pathogenesis is via a nonfunctioning elastase inhibitor (copper cofactor) or premature degeneration of elastic fibers. Although the skin signs tend to worsen with age, no wound-healing problems are reported. Blepharoplasty, rhytidectomy, and other skin contouring procedures pose no untoward risk and can be of great benefit to the patient. Some authors postulate an autosomal recessive inheritance, and others think the disorder results from a dominant mutation related to advanced paternal age. A familial link cannot be proved, however, because patients with progeria do not live long enough to reproduce. The disease progresses rapidly, and an early death is expected.

Werner Syndrome
Werner syndrome is often diagnosed during early adulthood when signs of indurated, plaque-ridden, and variably pigmented skin, aged facies, baldness, cataracts, short stature, and a high-pitched voice begin to manifest. Other features of the syndrome are mild diabetes mellitus, muscle atrophy, osteoporosis, premature arteriosclerosis, and various neoplasms.

Worldwide, Werner syndrome occurs in 1–2.2/1,000,000 people, although it is more common in Japan (1/300,000 people) and Sardinia (1/202,766 people). Werner syndrome is inherited as an autosomal recessive disorder. Because patients exhibit severe microangiopathy and the pathological mechanism has not been elucidated, elective surgery is contraindicated.

Elastoderma
The pathology and genetics of elastoderma are equally mysterious. As the name implies, the disorder is characterized by increased accumulation of elastic fibers in the dermis and subcutaneous tissues. The typical patient is a young female; the pendulous, extremely lax skin is at first confined to the trunk and extremities but later progresses to involve the entire body. Healing implications are not known, and surgery is not indicated.

Progeria (Hutchinson-Gilford Syndrome)
Progeria manifests as growth retardation, craniofacial disproportion caused by premature closure of epiphyses, baldness, a pinched nose, protruding ears, and micrognathia. Internally, loss of subcutaneous fat, arteriosclerosis or arterial calcification, and cardiac disease occur. The pathogenesis of progeria is still unknown. Affected children show lax, irregularly contoured skin with the pendulous folds and loss of subcutaneous fat typical of premature aging.

Some authors postulate an autosomal recessive inheritance, and others think the disorder results from a dominant mutation related to advanced paternal age. A familial link cannot be proved, however, because patients with progeria do not live long enough to reproduce. The disease progresses rapidly, and an early death is expected.

Meretoga Syndrome
Rintala et al. described an inherited, systemic form of amyloidosis that manifests clinically as excessively lax skin of the face in people who are at least 20 years old. The syndrome seems to be a facial polyneuropathy associated with amyloid deposits in the perineurium and endoneurium of peripheral nerves. The facial neuropathy helps differentiate
between this syndrome and congenital cutis laxa, which exhibits similar facial features.

Idiopathic Skin Laxity
In 1977, Shelley and Wood first described wrinkles as being caused by an idiopathic loss of mid-dermal elastic tissue, and similar findings have been noted by Rae and Falanga. Affected individuals typically show patchy areas of mid-dermal elastolysis manifesting externally as localized fine wrinkling without systemic abnormalities. The cause of the disorder is undetermined, although an antecedent inflammatory event such as urticaria is suspected.

AGE-RELATED CHANGES IN THE FACE

Gross Morphology
The classic description of the aging face presented by Gonzalez-Ulloa, Gonzalez-Ulloa and Flores, and Gonzalez-Ulloa et al. was based on the relations among 20 soft-tissue landmarks in the frontal, nasolabial, and mandibulocervical areas and their underlying skeletal structures as seen on radiographs of young and old study participants. The authors’ studies emphasized the need for objective parameters in reporting the results of aesthetic surgery.

Pitanguy et al. attempted to create a numerical model of facial aging on the basis of 22 facial parameters of 40 women measured at two different ages. Statistical analysis of the data showed remarkable similarity to the finding presented by Gonzalez-Ulloa and colleagues.

Yousif et al. analyzed changes in facial soft tissues occurring with age. The authors used historical photographs and photogrammetry to document a deepening of the nasolabial fold with concomitant inferior, lateral, and anterior displacement of the cheek mass and its support. In follow-up studies, Yousif and Gosain et al. observed that although the angle of the nasolabial fold decreased in older individuals, no significant difference was observed in the position of the fold relative to the philtrum or other structures of the lip. The difference in depth of the nasolabial fold between young and old subjects was largely because of descent of the subcutaneous cheek mass. Magnetic resonance images (MRI) of the patient in repose and smiling showed only downward movement of the skin and subcutaneous mass, with no discernible change or lengthening of the mimetic muscles.

For years, Lambros emphasized the importance of changes in volume of the facial skeletal and soft tissues in the aging process (V. S. Lambros, personal communication, 1999). Facial aging often manifests by deflation of the facial structures, both soft tissue and skeletal, and this deflation might be as important as gravitational laxity of the tissues.

Little addressed the loss of soft-tissue volume in facial aging. With the help of sculptural models, the author developed a surgical plan that redirects attention to the flat mid-face, particularly the malar and infraorbital areas, to restore a youthful appearance. Little called his approach a “three-dimensional rejuvenation of the mid-face: volumetric resculpture by malar imbrication.”

Age-related changes in the facial skeleton were studied by Bartlett et al. In their analysis of 160 Caucasian skulls, the authors noted appreciable reduction in facial height associated with aging. The decrease was most marked in the maxilla and mandible and correlated with loss of teeth. Also noted were modest increases in facial width and facial depth and generalized coarsening of the bony prominences.

Pessa verified the theory of skeletal remodeling with age, presented by Lambros (V. S. Lambros, personal communication, 1999), the premise of which is a clockwise rotation of the mid-face relative to the cranial base. Three-dimensional stereolithography confirmed narrowing of angles at the glabella, orbital, maxillary, and piriform points (Fig. 1).

Two important concepts emerged from this
study. First, the adult facial skeleton continues to grow throughout life in the absence of tooth loss or bone demineralization. Second, remodeling of the facial skeleton continues and can be summarized as rotation of the facial structures downward and inward with respect to the cranial base. These changes are most visible in the upper orbital area but are also present in the maxilla. Pessa speculates that the changes might be responsible for the “tear trough deformity” described by Flowers\(^79\) and the “negative vector orbits” described by Jelks and Jelks.\(^80\)

By using photographs of people’s faces linearly over time and superimposing matching pictures in the computer, Lambros\(^81\) assembled graphics interchange format animations by fading one image into another. The morphing revealed several findings: “1) the border of the pigmented lid skin and thicker cheek skin (the lid-cheek junction) is remarkably stable in position over time, becoming more visible by contrast, not by vertical descent as is commonly assumed; 2) orbicularis wrinkles on the cheek and moles and other markers on the upper mid-face were also stable over decades; and 3) with aging, there can be a distinct change in the shape of the upper eyelid.” The author noted that the young upper lid frequently has a medially biased peak whereas in the older upper lid, the peak becomes more central. He observed very little ptosis (inferior descent) of the lid-cheek junction or of the upper mid-face. These findings suggest that vertical descent of skin and, by association, subcutaneous tissue is not necessarily a major component of aging in those areas. Rather, the author suggested that much of the aging process is a result in changes in soft tissue volume and relative volume deflation in adjacent areas.

Stuzin\(^82\) described three themes common to all aging faces. First, there is descent of facial fat causing changes in facial shape. As ligamentous support becomes attenuated, facial fat descends anteriorly and inferiorly in the cheek leading to a squarer facial contour. Second, variable amounts of deflation of facial fat are noted. Soft tissue becomes less supported and lax. Lines of demarcation become apparent between regions of the face with the loss of smooth blending characteristic in youthful faces. Third, radial expansion of facial soft tissue occurs as a consequence of prolonged animation over time. Weakening of retinacular attachments causes skin and fat to prolapse outward.\(^82\)

**Histological Changes**

Three types of creases are possible in aging skin: animation creases from mimetic muscle insertions; fine, shallow wrinkles probably caused by disruption of the elastic structural network; and coarse, deep wrinkles produced by solar elastosis and the
epidermal atrophy of age.83

A great deal of experimental effort has gone into defining laxity of the skin, yet only sketchy evidence is available for the histological characteristics of skin wrinkles. Hashimoto,84 in 1974, first described two types of wrinkles in the skin. One is a shallow wrinkle that develops in sun-protected areas and disappears when the skin is stretched (temporary wrinkle). The second is a deep wrinkle on sun-exposed skin that does not disappear on stretching (permanent wrinkle). These findings have been confirmed by Tsuji et al.,85 Tsuji,86 and Rochefort et al.87 Furthermore, the permanent wrinkles brought about by actinic exposure can now be measured objectively by optical profilometry.88

Kligman et al.89 reviewed the published accounts and looked at human wrinkles through the microscope. They found no universal structural change on either routine histological sections or electron microscopy to explain the surface configuration and concluded that cutaneous wrinkles are essentially mechanically induced grooves of the skin in areas of frequent motion.

Tsuji and colleagues85,86 studied the histology of wrinkles by using light and electron microscopy and noted that deep wrinkles are formed by differential degrees of elastotic change in the dermis. They reported greater amounts of elastotic swelling on either side of the wrinkle than in the linear depression itself and theorized that the wrinkle represents a strip of relatively normal tissue surrounded on both sides by swollen, elastotic dermis.

Chatterjee et al.90 studied wrinkling in the ultraviolet B-radiated hairless mouse. They concluded that the increased tissue mass of the skin is a result of elastosis combined with proportionately lower collagen content that fractures the dermal collagen layer and produces a secondary wrinkle.

Lapière and Piérard and Lapière91 from Belgium explored the microanatomy of human skin furrows, particularly glabellar frown lines. The author noted thickened trabecular in the hypodermis that contain striated muscle cells. These apparent fascial insertions of cutaneous muscles create surface grooves on facial animation.

A histological study of human wrinkles92 documented atrophic and thin epidermis and hypodermis at the bottom of wrinkles, with interruption of the abnormal elastotic tissue deposits in the dermis at the base of the wrinkle and atrophy of dermal collagen and oxytalan fibers under wrinkles. Elastotic tissue pads on each side of a wrinkle add to the magnitude and depth of wrinkles. Biochemically, a marked decrease in chondroitin sulfate occurs in the papillary dermis under wrinkles and asymmetric variation in glycosaminoglycans on each flank of the wrinkle.

SURGICAL ANATOMY
Blood Supply to the Face
The classic study of circulation of the facial soft tissues was conducted by Manchot93 in 1889. Whetzel and Mathes94 updated the injection studies conducted by Manchot from the vantage point of modern technology in 1992 and defined 11 vascular territories of the face and scalp. The authors also note different patterns of perfusion in the face: Whereas the anterior portion of the face is supplied by numerous small musculocutaneous perforators, the lateral portion of the face is perfused by relatively few but large fasciocutaneous perforators in predictable locations.

Blanco-Dávila et al.95 described 11 pairs of musculocutaneous perforators supplying the facelift flap. These perforating vessels emerged from three main arterial trunks: the facial, superficial temporal, and ophthalmic arteries. All are connected by a rich anastomotic network that remains intact regardless of the plane of dissection. Because the perforating vessels are located primarily in the central (anterior) portion of the face, blood supply to the facelift flap is adequate as long as the dissection is not carried
Schuster et al.\textsuperscript{96} studied the vascular anatomy of the facelift flap and noted three adjacent vascular territories in the face, each of which is defined by specific perforating vessels and connected through anastomotic choke zones. The central vascular arcade consists of the angular artery, superior and inferior labial arteries, and nasal branch of the ophthalmic artery. The middle arcade consists primarily of the infraorbital and facial arteries and submental branch of the facial artery. The outer vascular arcade includes the zygomatico-orbital and transverse facial arteries (Fig. 2).

Whetzel and Mathes\textsuperscript{97} identified and localized the two main perforators supplying the cutaneous perfusion of the lateral face lift flap. The perforator from the transverse facial artery provides the direct blood supply to the lateral cheek and preauricular areas and has a constant anatomic location 3.1 cm lateral and 3.7 cm inferior to the lateral canthus with 95\% tolerance limits of ±1.1 cm. The submental perforating artery had much greater variability in its location. Both of the perforators are transected during a standard rhytidectomy dissection. The authors also performed subcutaneous and sub-superficial musculoaponeurotic system (SMAS) dissections, with transaction of the transverse facial artery perforator. They then conducted dye injection studies and found no difference in the cutaneous staining based on the plane of dissection.\textsuperscript{98} However, Schaverien et al.,\textsuperscript{99} using sequential dye injection and high-resolution three-dimensional computed tomographic (CT) angiography and venography found arterial branches within the SMAS forming a continuous anastomotic network. The superficial venous system was arranged in a polygonal configuration in the subdermal plexus, with no significant veins identified in the SMAS.

In 1984, Jost and Levet\textsuperscript{103} published a sharply critical reevaluation of the SMAS as described by their countrymen. After extensive anatomic dissections, they concluded that the SMAS was actually the remnant of the primitive platysma muscle of mammalian species, which in man encompasses four identifiable structures: the true platysma muscle in the neck, the risorius, the triangularis, and the auricularis posterior. The upper border of this muscular complex is at the zygoma.

The SMAS Layer
In 1976, Mitz and Peyronie\textsuperscript{100} presented a detailed anatomic description of the SMAS in the parotid and cheek areas. The authors noted that the SMAS was contiguous with the posterior portion of the frontalis muscle in the upper face and with the platysma muscle inferiorly. They showed that the only nerves superficial to the SMAS layer in the cheek are sensory branches, whereas the motor branches run deep to the SMAS. \textit{Gray's Anatomy of the Human Body}\textsuperscript{101} alluded to this fascial layer as early as 1859, and Skoog\textsuperscript{102} used it for plication and flap suspension in facelift years before the SMAS was formally described.

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The SMAS structures become less muscular and more fascial over the parotid gland to form the parotid fascia. Jost and Levet\textsuperscript{103} also identified a second layer of facial muscles located deep to the SMAS, oriented more vertically, and attached directly to the skull and facial bones. This layer includes the frontalis, periorbital, zygomaticus, and quadratus labii inferioris muscles and is similar to the sphincter colli profundus group (Fig. 3).

Jost and Levet\textsuperscript{103} argued that the only important fascia in the cheek is the deep fascia passing beneath the parotid gland to cover the masseter muscle. In their view, the fibrous extension of the primitive platysma forms the external portion of the parotid capsule, making it impossible to separate the SMAS from the deep parotid fascia\textsuperscript{104} so that one must elevate the capsule of the gland to elevate the musculofascial layer over the parotid. Mitz and Peyronie,\textsuperscript{100} on the other hand, described a multilayered fascia over the parotid and thought it represented adherent SMAS that was particularly dense 1 to 2 cm anterior to the tragus (Fig. 4). Despite the obviously different interpretations of these authors, the discrepancy seems to be mainly one of terminology rather than anatomy, and thus of only minor practical significance.

According to Jost and Levet,\textsuperscript{103} the primitive platysma (SMAS) ends at the level of the zygoma and does not continue to join the undersurface of the frontalis muscle. Mitz and Peyronie\textsuperscript{100} found the SMAS tightly adhered to the zygoma, which kept it from being elevated as a continuous layer. The readily seen fascial layer in the temple is frequently identified posteriorly as the temporoparietalis fascia and is contiguous anteriorly with the frontalis muscle. The temporoparietalis fascia contains the temporal vessels and the frontal branch of the facial nerve and might be part of a separate layer.

Mitz and Peyronie\textsuperscript{100} viewed the nasolabial fold as a cutaneous depression where the SMAS ends and as a distinct layer rather than as a fold caused by the insertions of specific muscles. The authors noted that at that point, the SMAS is deep, thin, and separated from the dermis by a large amount of fat. They noted that several thin muscle expansions run forward, slanting from the SMAS to the dermis, and that it is difficult to trace one of the muscle expansions to an underlying facial muscle or to the nasolabial fold at the surface.
Gosain et al.\textsuperscript{105} conducted anatomic dissections of the SMAS over the parotid region and cheek and examined whole-mount histological sections of the surgical specimens. The authors noted a separate, superficial “fascial-fatty” layer, which they considered to be distinct from the deeper SMAS, and concluded that the SMAS could be dissected off the parotid capsule and parotid fascia proper using a microsurgical technique. Additionally, they found no anatomic continuity between the SMAS below the zygomatic arch and the temporoparietal fascia above the arch. In the area of the lower eyelid, the SMAS was contiguous with the periorbital portion of the orbicularis, whereas the fascial-fatty layer extended superficial to the orbicularis muscle fibers.

Wassef\textsuperscript{106} studied the role of the SMAS in the anterior cheek by using fresh cadaver dissections (n = 14) and conducting retrospective analyses of surgical specimens after superficial parotidectomy (n = 39). The author found that the anterior and superior portions of the fibromuscular layer were attached to the zygomaticus muscle and that the muscular component of the fibromuscular layer becomes more prominent inferior to the labial commissure. The muscular component has somewhat horizontal fibers and corresponds to the risorius, platysma, and triangularis (depressor anguli oris) muscles.

The Nasolabial Fold
Attempts have been made to determine the exact anatomy of the nasolabial fold and the role of the SMAS in that area. Pensler et al.\textsuperscript{107} dissected the superficial fascia in the upper lip and examined it histologically. They found fascia just beneath the dermis in the upper lip and thought it to be contiguous with the attenuated cheek SMAS through the nasolabial fold. To smooth the fold, therefore, Pensler et al.\textsuperscript{108} suggested medial countertraction on the upper lip SMAS.

Webster et al.\textsuperscript{109} noted that tension transmitted across the nasolabial fold to the upper lip would deepen rather than flatten the nasolabial fold and concluded that the SMAS attached directly to the nasolabial crease.

Barton\textsuperscript{110} traced the SMAS layer from the parotid to the nasolabial fold using whole-mount histological sections obtained from fresh cadavers. The SMAS attenuated in the anterior cheek to become the investing fascia for the muscles of the upper lip. This anchoring effect on the SMAS by the zygomatic muscles means that lateral traction on the SMAS during facelift would have little effect on the medial cheek skin.

Barton\textsuperscript{111,112} and Pessa\textsuperscript{113} independently noted specific attachments of the SMAS to the mimetic muscles and the overlying skin and the effects of the attachments on the nasolabial fold. The authors showed that variable cutaneous expressions of the mimetic muscle insertions influence dynamic deepening of the fold.

Yousif et al.\textsuperscript{114} repeated the whole-mount histological and dissection study originally conducted by Barton\textsuperscript{110} and arrived at similar conclusions regarding the SMAS as an investing fascia of the mimetic muscles. The authors, however, thought that a separate, superficial fascial-fatty layer extended across the nasolabial fold to the cheek mass along the subdermal space. The layer, they thought, was anatomically and histologically distinct from the SMAS and played a role in fold dynamics: traction on the SMAS deepens the nasolabial fold, whereas traction on the fascial-fatty layer lessens the fold.

Retaining Ligaments
In addition to the horizontally distributed superficial fasciae of the face, vertical ligaments seem to extend from the bony skeleton directly or indirectly to the dermis. Furnas\textsuperscript{115} described osseocutaneous retaining ligaments in the cheek that extend from the periosteum of the zygoma and mandible to affix the skin to the underlying skeleton. Fibrous condensations of platysma fascia extend to the dermis. The author thought that the retaining ligaments (Fig. 5) explained the restricted motion of the cheek flap during facelift.
Stuzin et al.\textsuperscript{116} described other supporting ligaments that originate from relatively fixed facial structures, such as the parotid gland and anterior border of the masseter muscle, rather than periosteum (Fig. 6). The authors theorized that laxity of the supporting ligaments contributes to a deepening of the nasolabial fold and to the formation of jowls. Özdemir et al.\textsuperscript{117} presented a review of the literature on retaining ligaments of the face and their correction during rhytidectomy.

**Figure 5.** Retaining ligaments of cheek. Zygomatic and mandibular ligaments are osteocutaneous ligaments that tether skin to facial skeleton. Platysma-auricular ligament and anterior cutaneous ligaments are condensations of platysma fascia that extend to dermis. Art., artery; n., nerve; Gr., great; m., muscle. (Reprinted with permission from Furnas.\textsuperscript{115})

**Figure 6.** Retaining ligaments of cheek. Masseteric cutaneous ligaments and parotid cutaneous ligaments are fascial condensations that originate from relatively fixed facial structures and extend to skin. Attenuation of support from retaining ligaments is responsible for many stigmata of aging face. M., muscle. (Reprinted with permission from Stuzin et al.\textsuperscript{116})

Flaps of Skin, SMAS, or Composite Tissues

Har-Shai et al.\textsuperscript{118} studied the microscopic and biomechanical properties of preauricular SMAS excised during primary or secondary rhytidectomies. They found both dermis and SMAS to have similar histological components, with more fat and more elastin fibers present in the SMAS. The mechanical test on the SMAS specimen showed response characteristics similar to those of skin but with diminished viscoelastic properties (i.e., the stress relaxation effect was reduced). This property was said to explain the increased longevity of results in SMAS-based rhytidectomies.

Saulis et al.\textsuperscript{119} analyzed the biomechanical and viscoelastic properties of flaps of skin, SMAS, and composite tissues. The findings of their experimental analysis support the greater resistance of SMAS and composite flaps to stress-relaxation and creep than that of flaps of skin alone and provide experimental evidence for the clinically apparent increased longevity of rhytidectomy techniques that incorporate SMAS tissue for support.

Because skin flaps undergo apparent stress-relaxation after rhytidectomy, Yee et al.\textsuperscript{120} recommended intraoperative tissue expansion to increase the amount of skin that is excised and to compensate for the expected skin relaxation postoperatively.

Platysma Muscle

Vistnes and Souther\textsuperscript{121} studied the platysma muscle
of 14 cadaveric and 21 clinical dissections and found that in 61% of cases, the platysma decussated across the midline from the level of the hyoid cartilage to the mandibular symphysis, forming an effective muscular sling from the hyoid to the tip of the chin. The other 39% of specimens showed no such decussation; rather, the medial borders of the platysma continued parallel to each other to insert on the undersurface of the mandible. The latter arrangement gives rise to bilateral platysmal posts and the “turkey gobbler” deformity and allows the underlying submental fat to pseudoheurinate into prominence.

De Castro\textsuperscript{122,123} reproduced the study first conducted by Vistnes and Souther\textsuperscript{121} in a larger sample and found three different conformations for the platysma in the neck. In the most common arrangement (type 1, 75% of cases), the platysma proceeds cephalad as separate bands and only decussates for 1 to 2 cm below the edge of the mandible. In type 2 cases (15%), the platysma decussates all the way from the level of the thyroid cartilage to the mandible. The authors equated this type with the prevalent condition reported by Vistnes and Souther despite different anatomic landmarks. The remaining 10% of cases (type 3) show no platysmal decussation.

Facial Nerve

The course of the facial nerve and its branches is of the utmost importance to rhytidectomy. Baker and Conley\textsuperscript{124} studied the course of the facial nerve in more than 2000 dissections and noted that in the cheek, the major nerve divisions communicated approximately 70% of the time whereas the frontal and mandibular branches usually were terminal and showed crossover communications only in 15% of cases. The depth of the facial nerve in facelift dissections has been studied by Rudolph\textsuperscript{125} using 12 cadaver head halves. The average depth of the nerve from the skin surface was 9 to 10 mm for the peripheral branches at their exit from the margin of the parotid gland.

The exact location of the frontal branch in relation to the SMAS is critical to a safe dissection in the temple. In their classic article of 1966, Pitanguy and Ramos\textsuperscript{126} described the frontal branch of the facial nerve as coursing approximately along a line from 0.5 cm below the tragus to 1.5 cm above the lateral end of the eyebrow (Fig. 7). The anterior branch of the temporal artery often accompanied the nerve. Ishikawa\textsuperscript{127} described the anatomic distribution of the temporal branch of the facial nerve based on 30 cadaveric dissections. The frontal branch sometimes courses as high as 4 cm above the lateral canthus.

Gosain et al.\textsuperscript{128} studied the course of the temporal branch of the facial nerve in fresh cadavers. The authors noted considerable differences in location and arborization pattern of the nerve and discussed the relevance of their findings to rhytidectomy. They included an extensive bibliography of facial anatomic studies in their article.

Mitz and Peyronie\textsuperscript{100} noted that the frontal branch lies deep to the SMAS in the temporal region, whereas Correia Pde and Zani\textsuperscript{129} found

![Figure 7. Location of frontotemporal branch of facial nerve.](Reprinted with permission from Pitanguy and Ramos\textsuperscript{126})
branches of the facial nerve lying in the superficial portion of the fascial aponeurosis (or what has come to be recognized as the temporoparietalis). Liebman et al. concurred and noted that the frontal branch lies within the fascial layer for a large part of its course above the zygoma and becomes progressively more superficial as it approaches the brow.

Stuzin et al. studied the relationship between the frontal branch of the facial nerve and temporal fascia. The frontal branch of the facial nerve traverses the temporal region in a constant anatomic plane along the underside of the temporoparietal fascia. They found three fascial layers in the temporal area: the temporoparietal fascia, the superficial layer of the deep temporal fascia, and the deep layer of the deep temporal fascia. Beginning at the level of the superior orbital margin and continuing inferiorly to the zygomatic arch, the two layers of deep temporal fascia are separated from each other by the superficial temporal fat pad. To protect the frontal branch of the facial nerve when exposing the fronto-orbital area during rhytidectomy, the authors dissect in the plane beneath the superficial layer of the deep temporal fascia.

The course and depth of the frontal branch at the zygomatic arch is of particular importance and has been elucidated by Trussler et al. Using fresh cadaver heads, the frontal branch of the facial nerve was noted to travel beneath the parotid-temporal fascia, a separate fascial plane, deep to the SMAS (Fig. 8). In their dissections, the parotid-temporal fascia protects the frontal branch during sub-SMAS dissection in a high-SMAS facelift. Stuzin commented that the parotid-temporal fascia might be similar to the subgaleal fascia described by Tolhurst et al.

Two other studies of the branching pattern of the mandibular ramus used dissection and nerve stimulation during facial surgery. In the dynamic state, several branches of the mandibular ramus were noted to dip approximately 3 to 4 cm below the inferior border of the mandible. The mandibular branch innervated the upper and anterior portions of the platysma in at least 50% of the cases, whereas the descending cervical branch of the facial nerve innervated the main body of the platysma.

Park described a percutaneous method of mapping the facial nerve branches preoperatively. The method is likely impractical for routine cases but might be helpful in cases of secondary surgery.

In 1974, Rubin correlated specific muscle actions with the type of smile pattern produced. Two years later, Baker and Conley determined that the full-denture smile—pulling the lower lip down and to the side and everting the vermilion—was the result of contraction by the depressor anguli oris and the depressor labii inferioris. The platysma is a significant active depressor only in a small percentage of patients.

Cervical Sensory Nerves
The great auricular nerve, although not part of cranial nerve VII but rather a sensory branch from the cervical plexus, is nevertheless an important structure in rhytidectomy. McKinney and Katrana studied the course of the great auricular nerve and described some external landmarks to help locate it. They are as follows:
1. With the head turned 45 degrees in the facelift position, the great auricular nerve consistently crosses the belly of the sternocleidomastoid muscle at its midpoint approximately 6.5 cm below the caudal edge of the bony external auditory canal.

2. The nerve runs in close proximity to the external jugular vein lying just beneath the skin and SMAS.
Later, McKinney and Gottlieb\(^{140}\) suggested that the safest place to penetrate the SMAS-platysma during facelift is at a point immediately in front of the anterior border of the sternocleidomastoid, because the nerve runs deep into the parotid after it wraps around the muscle. Izquierdo et al.\(^{141}\) noted that the postauricular branches of the great auricular nerve extend no farther than 1.5 cm posterior to the attachment of the lobule into the cheek. They recommended placement of mastoid tacking sutures during rhytidectomy beyond that point (i.e., at least 1.5 cm behind the insertion of the lobule).

Somewhat overlooked in the rhytidectomy literature is the lesser occipital nerve and its sensory branches to the upper ear. Pantaloni and Sullivan\(^{142}\) mapped the course of the lesser occipital nerve and found that branches of the lesser occipital nerve innervated the superior one-third of the ear and mastoid area in 58% of cases (Fig. 9). In 21% of specimens, the lesser occipital nerve supplied the superior two-thirds of the ear. In an additional 5% of faces, the lesser occipital nerve innervated the majority of the ear except the earlobe. The nerve traveled most often over the sternocleidomastoid muscle fascia, running between the muscle fascia and the SMAS. In some specimens, the nerve ran in a superficial subcutaneous plane and was thus vulnerable during rhytidectomy dissection.

Fat Compartment of the Face
Rohrich and Pessa\(^{143}\) performed detailed cadaveric studies with the use of dye injection techniques and dissection to identify multiple independent anatomic compartments partitioning the subcutaneous fat of the face (Fig. 10). The nasolabial fat and jowl fat are separate independent compartments. The malar fat is divided into three separate compartments: medial, middle, and lateral temporal-cheek fat. The forehead also has three compartments, including central, middle, and lateral temporal-cheek fat. The lateral temporal-cheek fat is the only compartment that spans the height of the face, connecting the temporal fat to the cervical

Figure 9. Great auricular nerve, lesser occipital nerve, and auriculotemporal nerve provide sensory supply to ear and periauricular area. (Reprinted with permission from Pantaloni and Sullivan.\(^{142}\))

Figure 10. Subcutaneous compartments of face. (Reprinted with permission from Rohrich and Pessa.\(^{143}\))
subcutaneous fat. The periorbital has fat is divided into superior, inferior, and lateral compartments. Separate from the superficial fat is the deep medial fat compartment.144 This compartment abuts the pyriform membrane and lies directly on the maxilla.

Histological evaluation identified fibrous condensations of connective tissue forming barriers to diffusion of dye between compartments. The septa spanned the subcutaneous space, running from the underlying fascia and inserting into the dermis of the skin. This interconnecting framework forms a retaining system for the face.145 Perforator blood vessels to the skin are identified in the condensations of fascia. The retaining system provides stability and protection for the vascular supply. Each anatomic compartment had an identifiable vessel along its boundary.146

Deep Fat
Kahn et al.147 studied the anatomy of the deep adipose structures of the face. The buccal fat pad is multilobular and extends into the deep temporal, pterygoid, and even lower orbital areas. The buccal fat pad functions as an intermuscular sliding plane. The histology of the deep fat and its immobile nature are also discussed.

HISTORY OF RHYTIDECTOMY
The following historical notes on rhytidectomy are taken from the excellent reviews presented by Rogers148 in 1976 and Gonzalez-Ulloa149 in 1980.

The concept of a surgical “lift” as we know it today probably originated with Hollander150 in 1901. Other early reports of facial rejuvenation were presented by Miller,151−153 from 1906 to 1908, and Kolle154 in 1911. In 1910, Lexer155 combined a temporal incision with a separate inferior and postauricular incision to extend the reach of the facelift procedure. Apparently, Lexer was also the first to undermine the skin flaps in the subcutaneous plane. Passot,156 in 1919, used multiple small skin excisions and originated the submental incision for dealing with a “double chin.” Bettman,157 in 1920, was the first to present for publication before and after photographs of a patient undergoing a facelift. He also pioneered the use of a very long incision that joined the temporal and preauricular regions and extended into the mastoid and occipital areas, much like the modern incision.

Early attempts at facelift consisted primarily of skin excision with direct closure. These procedures depended on tension at the closure to elevate the cheek and neck tissues. In 1927, Bames158 saw the problem with this and recommended undermining the skin in the subcutaneous plane, as Lexer155 had suggested 17 years earlier. For the next half-century, the basic rhytidectomy procedure consisted of subcutaneous dissection and redraping of the cheek and neck skin.

Pangman and Wallace159 are attributed with first describing, in 1961, what later came to be known as the SMAS layer. In retrospect, their technique is surprisingly similar to the technique described by Skoog102 in 1974. The authors raised the skin and “superficial fascia” as a common layer, carrying the tension on the cheek flap on sutures placed above the zygomatic arch into the deep temporal fascia.

It was not until the book written by Skoog102 was published in 1974 that deep-layer suspensory techniques became popular. Shortly thereafter, Mitz and Peyronie100 described the SMAS in the face, and the present era of facelift by suspension of the SMAS-platysma layer was born. Larson160 traced the evolution of rhytidectomy techniques in the 20th century.

Neck defatting procedures date to Passot156 in 1919 but were largely ignored until the 1968 report presented by Millard et al.161 In the mid-1960s, Adamson et al.162 directed their attention to the problem created by bands of platysma in the submental region. More recently, subperiosteal dissection of the forehead has been continued around the orbital rims and into the cheek.163,164
EVOLUTION OF THE PROCEDURE

In recent years, the goals of rhytidectomy have shifted away from smoothing the nasolabial and labiomandibular folds to more subtle manipulations of the periorbital and mid-facial areas. Clinicians have come to realize that atrophy and descent of the facial structures is a major part of the aging process. The nasolabial fold, for instance, is not a large wrinkle but rather a point of shelving for the descending facial subcutaneous mass; the depth of the nasolabial fold, therefore, is merely an index of cheek descent. Recognizing that the lower eyelid blends imperceptibly into the upper cheek, rhytidectomy surgeons are now focusing on elevating the malar soft tissues and softening the suborbital tear trough.

Matarasso et al.\textsuperscript{165} reviewed the facelift techniques currently used by plastic surgeons in clinical practice and the associated complications. Questionnaires were prepared and distributed to 3800 board-certified plastic surgeons. Five hundred seventy (15%) of those solicited to participate in the study responded. Analysis of the data revealed current preferences in facelifting techniques, including incision location, level of SMAS dissection, modified facelift techniques, and preferences regarding treatment of malar fat pads, submandibular glands, and submental regions. The authors summarized the findings as follows:

“Three basic conclusions can be gleaned from this study: (1) Surgeons perform more tried and true methods of aesthetic surgery, rather than the many new methods that seem to get the most attention in the media and at the meetings. (2) It seems that less-experienced surgeons tend to be generally more conservative in their approach to aesthetic surgery. (3) Complication rates reported by the plastic surgery community at large coincide with previous complication rates, as outlined in other nonsurvey studies.”

PATIENT SELECTION

The proper selection of patients for facelift is as important to the outcome of the procedure as the choice of operative technique and the surgeon’s ability. For more on this complex subject, we refer the reader to articles by Edgerton et al.,\textsuperscript{166} Baker,\textsuperscript{167} Goin et al.,\textsuperscript{168} and Lavell and Lewis.\textsuperscript{169} It is important to note that many surgeons recommend comprehensive aesthetic analysis and complete balanced rejuvenation of the face.\textsuperscript{170-173}

OPERATIVE TECHNIQUES

Subcutaneous Dissection

The classic facelift changed little from the time of Bames\textsuperscript{158} in 1927 until the mid-1960s, and even then, the changes involved mostly the incision and not the surgical concept. The extent of subcutaneous undermining performed varies among surgeons,\textsuperscript{174-178} but the modern trend has been for more rather than less.

Regarding his extended supraplatysmal plane (ESP) dissection, Hoefflin\textsuperscript{179} recommended carrying all subcutaneous fat down to the fascial layer of the SMAS as a single unit attached to skin (Fig. 11). The author reported that by leaving the thicker subcutaneous layer on the flap, the osteocutaneous ligaments can be thoroughly released and sculpting around the neck and jowls can be achieved under direct vision to produce a more natural contour.

Subcutaneous Facelift with Deep Plication

In 1960, Aufricht\textsuperscript{180} indicated the shortcomings of the standard subcutaneous dissection procedure, particularly in patients with jowls, fatty accumulations in the submental area, or platysmal bands. For the next 15 years or so, most modifications of the rhytidectomy technique included deep suture-plication of tissues;\textsuperscript{166,181,182} specifically, to supplement the subcutaneous lift, the fatty tissues of the cheek and neck were suspended upward and laterally without undermining the SMAS.

Duffy and Friedland\textsuperscript{183} presented a report
of 750 patients who were treated by extensive subcutaneous facelift and peripheral (periauricular) SMAS plication. Their article details the modern approach to the Pangman-type facelift. Other proponents of subcutaneous dissection and SMAS plication include Hamilton,\textsuperscript{184} Cárdenas-Camarena and González,\textsuperscript{185} and Pitanguy.\textsuperscript{186}

Wide subcutaneous undermining with anterior SMAS plication has been advocated by Robbins et al.\textsuperscript{187} The author folds in the SMAS anteriorly just lateral to the oral commissure, without excision or undermining. The idea is to produce a more direct effect by plicating the SMAS anteriorly, where the redundancy occurs, rather than peripherally in the face.

**Skoog Procedure**

In his 1974 textbook, Skoog\textsuperscript{102} described a technique of rhytidectomy that elevated the skin and SMAS as a single unit, which was then advanced posteriorly onto the cheek and neck. The implication was that the sturdy SMAS could be used to transmit a stronger and more lasting suspensory pull on the facial tissues. The method presented by Skoog method had a major impact on facial aesthetic surgery for its identification of the SMAS as a discrete layer that could be used to augment skin suspension.

Shortcomings of the Skoog procedure were soon noted, however. These had to do primarily with insufficient transmission of tension across the cheek that failed to improve the nasolabial folds and a similar attenuation of pull in the anterior neck. In the decades since Skoog’s original description, myriad modifications have attempted to overcome these limitations.

Webster et al.\textsuperscript{188} challenged the effectiveness of wide subcutaneous undermining, contending that minimal undermining and closure of the skin incision under tension achieves as much facial improvement as more extensive undermining and with much less risk to the facial nerve. The authors, in another article,\textsuperscript{109} compared SMAS plication (suture infolding) with SMAS imbrication (incision, advancement, and overlapping) and concluded that plication achieved the same amount of facial mobility as did undermining and advancement, apparently because of the areolar plane beneath the SMAS. Webster et al. hypothesized that traction on the SMAS would accentuate the nasolabial groove and that secondary advancement of the cheek skin would be necessary to soften the nasolabial fold. This hypothesis contradicts the current scientific data on the anatomy of the nasolabial fold and clinical experience.

In 1980, Lemmon and Hamra\textsuperscript{189} presented their experience with 577 Skoog rhytidectomies. Early in the series, patients underwent a classic Skoog procedure, which was subsequently modified when the authors noted early recurrence of skin folds in the anterior neck and relaxation of the submental skin.

Barton\textsuperscript{110} showed the SMAS to be the investing fascia of the zygomaticus major and other
mimetic muscles. This fusion of the muscle origins and investing fascia to the bone at the zygomatic prominence was responsible for restriction of anterior pull on the cheek flap by the Skoog procedure. To smooth out the fold, Barton\textsuperscript{111,112} broke through the investing fascia at the lateral border of the zygomaticus major muscle and continued the anterior dissection in a subcutaneous plane (Fig. 12).

Barton\textsuperscript{112} retained the attachments of the SMAS to the cheek flap over the zygoma and deep temporal fascia. He reported that the high purchase of SMAS combined with a mainly upward vector of advancement created a vertical lift of the entire soft-tissue mass from mandible to zygoma. The orbicularis oculi muscle, which is not suspended by this technique, is dealt with separately.

A similar procedure was proposed by Jost et al.\textsuperscript{190} Their modification freed the SMAS from the lateral zygomaticus muscle but involved a more limited anterior dissection. Pessa\textsuperscript{113} performed selective transection of the muscles to accomplish the same objective.

In 1990, Hamra\textsuperscript{191} presented an update of his deep-plane experience, which embraced the concepts of anterior release of the investing fascia from the zygomaticus major muscle while carrying the subcutaneous cheek fat on the skin. That technique was further modified in the composite rhytidectomy presented by Hamra,\textsuperscript{192-195} with which not only platysma and subcutaneous fat but also the lower lid orbicularis muscle are treated as a single dissected unit (Figs. 13 and 14).

SMAS imbrication with the composite technique presented by Hamra\textsuperscript{192-195} is in the buccal and mandibular areas, much as with the procedures later adopted by Robbins et al.\textsuperscript{187} Hamra\textsuperscript{194-196} has since focused on the malar and periorbital areas and has added direct suspension in the upper face to his rhytidectomy procedure.

Pina\textsuperscript{197} reported his experience with 145 composite rhytidectomies. The author reported satisfactory results overall except for three cases of transient weakness of the lower eyelid with spontaneous recovery occurring in 4 weeks.

![Figure 12](image1.png)

Figure 12. Dissection proceeds medially in sub-SMAS plane until reaching level of lateral border of zygomaticus major muscle and is then continued subcutaneously. (Reprinted with permission from Barton,\textsuperscript{112})

![Figure 13](image2.png)

Figure 13. Lower extent of zygorbicular dissection (upper hemostat) and upper extent of deep plane facelift (lower hemostat) overlap but do not communicate with each other. (Reprinted with permission from Hamra,\textsuperscript{194})
Subcutaneous Dissection with Deep SMAS Advancement

Another school of thought advocates splitting of the musculocutaneous cheek flap into single components that are handled separately. Proponents of this theory view the SMAS as a foundation layer that is dissected and advanced independently from its overlying skin, which is stretched and redraped separately.

Owsley\textsuperscript{198,199} analyzed the results of 80 Skoog rhytidectomies that were modified to include undermining from the zygomatic arch to the deep cervical area but no dissection over the mandibular angle and ramus (to protect the marginal mandibular nerve). He concluded that the results obtained with the Skoog procedure were more definite and longer lasting than with the subcutaneous technique but at the expense of longer operating time and the greater care needed to avoid injury to the facial nerve. Mendelson\textsuperscript{200} and de Castro\textsuperscript{201} reported their respective experiences with two-plane dissection and SMAS imbrication, as are used with the Owsley technique.\textsuperscript{202}

Stuzin et al.\textsuperscript{203} described a technique of peripheral SMAS imbrication that was somewhat similar to the technique presented by Owsley.\textsuperscript{202} The dissection rotates on the prominence of the zygomaticus major muscle, and the SMAS is suspended to the periosteum of the zygomatic arch with permanent sutures (Fig. 15). Similarly, Pitanguy\textsuperscript{204} described his “round block” technique, which combines SMAS imbrication to treat the lower face and neck and incorporates direct suture repositioning of the malar fat pad in treatment of the mid-face. In 2000, Stuzin et al.\textsuperscript{205} folded Vicryl mesh into the upper edge of their SMAS flap to ensure a secure fixation point along the zygomatic body and arch.

It is anecdotally known that many plastic surgeons elevate a rather lengthy SMAS flap that starts in the preauricular area and is suspended in the temporal region. A different approach was taken by Hamra,\textsuperscript{193} Hagerty and Sciscia,\textsuperscript{206} and
Baker,207,208 who prefer to excise a strip of SMAS in the region overlying the anterior edge of the parotid gland (Fig. 16). Stuzin82 and Rohrich et al.172 have both introduced the idea of facial shaping and have put forth an algorithm to direct the vector of SMAS plication depending on the facial height, width, and fullness.

The width of SMAS resection varies with the degree of laxity of the tissues. The cut edge of the SMAS flap and its accompanying soft tissue are then sutured to the fixed parotid fascia. This type of lateral SMAS excision and imbrication has come to be known as the strip SMASectomy.207,208 The main disadvantages of dissecting the SMAS and skin separately are that it precludes supplemental perfusion of the cheek flap by the platysma and that the dermis, not the fascial aponeurosis, must carry the closing tension on the skin.209,210

**Figure 15.** Excess SMAS, rather than being excised, is rolled on itself and sutured to the periosteum of zygomatic buttress. Fixation is as important as adequate SMAS mobilization. *(Modified from Stuzin et al.)*

Temporal Subperiosteal Dissection

In 1980, Tessier211 first suggested lifting the soft tissues of the cheek and forehead by the subperiosteal technique and subsequently wrote about it in the French medical literature.163 The method was taken up and modified by Psillakis et al.,212 who continued the periorbital dissection of the subperiosteal lift around the zygomatic body to improve its effect on the cheek.

Hinderer et al.213 continued the temporal dissection to a deep plane beneath the superficial layer of the deep temporal fascia, as advocated by Stuzin et al.,131 and reported no damage to the frontozygomatic branches of the facial nerve in 65 patients undergoing this procedure from 1983 to 1987. Hinderer,214 Tapia et al.,215 and Fuente del Campo216 subsequently updated their respective experiences with the subperiosteal technique in rhytidectomy.

Ramírez et al.217 took the extended subperiosteal facelift one step further. They continued the subperiosteal dissection all the way across the maxilla and to the lateral nasal walls to gain maximum beneficial effect on the cheek and nasolabial areas. The authors claimed that traction...
on the mimetic muscles to the upper lip and medial cheek elevated the corners of the mouth and relieved oral “frowning.” Deep periosteal tacking sutures are used to enhance the soft-tissue suspension. Because the dissection is deep to both layers of the temporal fascia, risk of injury to the frontalis nerve is lessened. Ramirez and others expanded the technique to include dissection over the massteric fascia and intraorally to mobilize the entire cheek.

Krastinova-Lolov reported 200 cases of aesthetic subperiosteal rhytidectomy by a technique similar to that presented by Ramirez et al. Heinrichs and Kaidi presented a series of 200 subperiosteal facelifts with very pleasing results (Fig. 17). An additional description of the subperiosteal technique in mid-facial and periorbital rejuvenation, with an emphasis on periorbital dissection, was presented by Hobar and Flood.

Little reported his experience with the combined temporal and perioral subperiosteal mid-face release. Little stacked the entire cheek soft-tissue unit to further accentuate the malar eminence: after initial subperiosteal release, a deep suture is placed low in the undersurface of the cheek flap, and the cheek surface is bunched over the malar area (Fig. 18). The surface irregularity is then smoothed by suture plication of the superficial subcutaneous tissues.

Scheflan et al. presented a discussion of complications of subperiosteal facelifting and how to avoid them. Psillakis et al. initially reported 11% transient injury of the frontal branch of the facial nerve, presumably resulting from traction on the nerve.

The subperiosteal technique allows adequate redraping of the forehead and malar areas. The perioral region and neck, however, almost always require additional, direct skin suspension to successfully eliminate redundancy. Patients with a great deal of skin redundancy in the nasolabial folds, jawline, and neck are not considered candidates for a subperiosteal procedure.

A continuing controversy regarding subperiosteal facelifting has to do with releasing and repositioning the origins of the mimetic muscles, particularly the zygomaticus major muscle. Proponents of the technique emphasize that this will have a favorable effect on the ptotic

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Figure 17. Subperiosteal dissection is continued over tendon of masseter. (Reprinted with permission from Heinrichs and Kaidi.)

Figure 18. Malar imbrication with suture tied to deep temporal fascia and subcutaneous plication. (Reprinted with permission from Little.)
oral commissure, as exemplified by the procedure presented by Marinetti. Critics of the technique claim that cheek ptosis is more pronounced in the subcutaneous and dermal layers, so that shifting the mimetic muscles adds little to the technique but may alter the natural facial animation.

Maillard combined a deep SMAS flap with an extended subperiosteal dissection in an attempt to alleviate the shortcomings of the subperiosteal facelift. Yaremchuk advocated combining upper lid blepharoplasty, transconjunctival retroseptal fat excision, lower lid skin excision, and full-thickness skin rhytidectomy with a subperiosteal lateral brow and mid-face elevation in an effort to rejuvenate the entire face and overcome the limitations of an isolated subperiosteal approach. The exact role of subperiosteal dissection alone or in combination with other techniques remains to be determined.

Temporal Supraperiosteal Dissection
De la Plaza and colleagues described a procedure they called supraperiosteal facelift, which they had performed in 128 patients. With this procedure, the flap is elevated following the natural plane between the SMAS and the periosteum around the zygomatic arch. The dissection is then continued along what the authors described as a convenient and avascular dissection plane, below the orbicularis oculi muscle, and continues above the malar bone and the insertion of the zygomatic muscles. The flap is dissected past the infraorbital nerve foramen and suspended with deep sutures, similar to the procedure presented by Ramirez et al. Although the specific differences between the procedure presented by De la Plaza and colleagues and other subperiosteal techniques seem relatively minor, the articles by De la Plaza and co-authors illustrate the evolution of thought regarding ways to apply craniofacial surgical principles to aesthetic surgery of the upper face.

Byrd and Andochick and Hunt and Byrd modified the subperiosteal approach to the temporal region by addressing the bony and soft tissues in the upper face as a single unit.

Abandoning the subperiosteal plane, Byrd dissected supraperiosteally around the lateral orbital rim and into the malar area. Unlike the subperiosteal approach, this dissection proceeds superficial to the origin of the zygomaticus major and other mimetic muscles, with care taken to avoid injury to the orbicularis. The malar pad is then independently suspended by sutures from the upper temporal fascia. Seify et al. used the same dissection planes to perform endoscopy-assisted facelifts on 200 patients and achieved excellent results. Hinderer reported extensive experience with the temporal approach to supraperiosteal mid-face cheek lift dating back to the mid-1980s and his work around the periorbital area.

Minimal Access Cranial Suspension (MACS) Lift
The purse-string suture suspension technique of using a strong, permanent suture to lift sagging facial features was first described by Saylan and subsequently modified and popularized by Tonnard and Verpaele and Tonnard et al. The MACS lift is a short-scar technique that uses a preauricular and temporal pre-hairline incision combined with submental preplatysmal liposuction. The MACS lift uses two purse-string sutures. The first suture is a vertical U-loop anchored to the deep temporal fascia, then sequential 1- to 1.5-cm-long bites of the SMAS and platysma down to the mandibular angle, then returning to the origin, and tied. The second suture is an oblique oval loop starting at the same point, angled 30 degrees, and run down to the jowl area and returning to the origin. An extended MACS lift incorporates a third suture anchored at the lateral orbital rim and looped obliquely downward and medial to suspend the malar fat pad (Fig. 19).

Emerging Technologies and Minimally Invasive Techniques
The plastic surgery literature is replete with suggestions and modifications for reducing problems with scarring and delayed healing and the high risk of complications and revision surgery associated with traditional procedures. Recent
attempts have focused on the development of nonsurgical or minimal-incision techniques of facial rejuvenation.

Sulamanidze et al.\textsuperscript{236,237} and Lycka et al.\textsuperscript{238} proposed the use of subdermal suspension with barbed sutures to lift the ptotic mid-face. Although only minor improvements in facial contour were evident from the clinical photographs, the authors argued that the technique was indicated in patients with early aging changes in the face. Several authors\textsuperscript{239−241} have presented series with follow-up durations ranging from 6 to 12 months. It seems that improvement in the mid-face is more sustained than the lower face, jowls, or neck. One series states that the results begin to fade by 6 months, with almost complete loss of correction by 12 months.\textsuperscript{239} A different series stated that some clinical efficacy was noted up to 16 months after the procedure. However, no photographs of sustained follow-up were presented.\textsuperscript{240} In a large series of 72 patients, Garvey et al.\textsuperscript{241} found that 42% underwent some form of revision surgery an average of 8.4 months after their original threadlift procedure. Eleven percent of patients required thread removal for palpability. Overall, little long-term follow-up is available to allow accurate assessment of the effectiveness of this technique.\textsuperscript{242}

\textbf{Figure 19.} Schematic representation of incision, area of undermining, anchor points, and placement of first, second, and third purse-string sutures. In case of single MACS lift, only first and second sutures are placed, originating from same anchor point 1 cm above zygomatic arch and 1 cm in front of helical rim. Incision will then be a little shorter and extend up to level of lateral canthus. (Reprinted with permission from Tonnard and Verpaele.\textsuperscript{234})
Most series cite the technique’s short down time and safety profile; the procedure is not completely benign. Bruising is seen in 40% to 60% of patients, and swelling is seen in 15% to 50%. Thread palpability or visibility can occur in 20% to 36% of patients. Overall, the complications are minor, thread removal is relatively simple, and traditional rhytidectomy is still possible after thread placement. Anecdotal reports of more serious complications have been presented, including Stensen duct rupture, facial weakness, and chronic foreign body reaction.

Sasaki et al. conducted a cadaver study comparing holding tension, slippage tension, and pull-out tension for eight suspension suture systems. The authors found that holding tension was higher for the expanded polytetrafluoroethylene (ePTFE) knotted looped suture (W. L. Gore & Associates, Flagstaff, AZ) than for other systems. The overall tension profiles for Silhouette (Kolster Methods, Inc., Corona, CA) and Woffles suture and ePTFE were higher than the other available products. Approximately 50% of barbs or cogs of polypropylene and polydioxanone sutures were observed to bend, curl, or strip away from the suture body after extraction. The authors concluded that the currently available suture suspension systems vary significantly. Their study was limited by the small number of samples, possible variability in techniques for suture placement, and differences between fresh-frozen cadaver versus living tissue.

The use of lasers and non-ablative technologies such as radiofrequency therapy for facial rejuvenation is currently popular. These topics are discussed in the “Lasers in Plastic Surgery” issue of Selected Readings in Plastic Surgery.

OUTCOME STUDIES
On the basis of a sophisticated angiographic study, Schuster et al. found that a two-layer rhytidectomy was most disruptive to the underlying blood supply. Composite-type Skoog procedures and superperiosteal approaches altered the normal facial circulatory pattern only minimally.

Attempts to scientifically study the holding power of SMAS suspension in enhancing durability of facelift surgery have met with variable success. Forrest et al. analyzed the biomechanical effects of deep fixation of the SMAS on skin tension at closure and not unexpectedly found that tension on either side of the suture line was significantly less when the weight of the cheek was borne by the deep layer. The authors hypothesized that the support by the deep tissues counteracts secondary stress relaxation of the skin flap and helps maintain the surgical improvement over the long term.

Gamble et al. used tension measurements to determine relative strengths of skin closure in standard subcutaneous rhytidectomy and composite techniques. The authors found that the composite facelift resists stretch better than facelifts performed with the subcutaneous method. One should remember that these observations reflect immediate measurements in cadavers and do not necessarily predict the long-term clinical outcome of tissues subjected to in vivo influences.

Ivy et al. and Kamer and Frankel attempted to evaluate the outcomes of various techniques of rhytidectomy with SMAS dissection. Subjective evaluation conducted 12 months after surgery showed little if any difference between procedures. Kamer and Frankel thought the composite technique presented by Hamra was associated with fewer revisions, which they inferred to mean it produced longer lasting results.

Efforts to compare the outcomes of different types of facelift techniques led to the conception of the twin study in 1995. Four facelifts were performed on two sets of identical twins by four different surgeons. The results were followed for 10 years and the findings were presented and discussed at 1, 6, and 10 years postoperatively at the annual meeting of the American Society for Aesthetic Plastic Surgery. Although it is impossible to tell which patient had the “best” result, several things became clear. First, all four patients looked significantly younger 10 years after surgery than
they did before surgery. Second, each surgeon cited their ability to use a technique that was consistent, reliable, predictable, and reproducible.\textsuperscript{251}

Liu and Owsley\textsuperscript{252} examined the timing of a facelift and its impact on long-term patient satisfaction and aesthetic outcomes. Using patient surveys and long-term photographic follow-up, the authors found that patients younger than 50 years consistently had greater satisfaction and longer lasting aesthetic improvement. They concluded that younger patients, even with minimal signs of aging, are candidates for facelift surgery.

A comparative assessment of both the quality and longevity of results of the myriad rhytidectomy techniques suffers from the lack of a reproducible, objective scale for judging improvement. Clinical grading methods are highly subjective and observer-dependent and are therefore unreliable. A comprehensive review of the literature revealed that assessment tools fall into one of four categories: objective, satisfaction, psychological, and quality of life (QOL).\textsuperscript{253}

The authors of that comprehensive review\textsuperscript{253} identified only five studies that used objective assessments to evaluate cosmetic surgery. Among the five studies, only one method—that used by Tapia et al.\textsuperscript{254}—had been used to evaluate patients undergoing surgery. Tapia et al. proposed a system that digitally analyzes images obtained before and after surgery by measuring distances and angles between multiple reference points and assigning them scores. This complex photo computer analysis method emphasizes the need for a simple, office-based, reliable scheme for assessing changes brought about by plastic surgery.

Instruments used to assess satisfaction were widely variable and were often developed by the researchers using the instrument. None of the instruments had undergone tests of validity and reliability.\textsuperscript{255} Thirty-four psychology-based instruments were identified and represented the majority of outcome measures that have been used in cosmetic surgery. However, considering that these instruments were developed for psychopathology, many of the scales lacked face and content validity regarding aesthetic surgery.\textsuperscript{253} Eight quality-of-life assessment scales that had been used for evaluation of cosmetic surgery were identified. One, the Derriford Appearance Scale, was specifically developed for use with plastic surgery.\textsuperscript{253,255,256} In conclusion, the authors identified several instruments that had potential value for further development: The Multidimensional Body-States Relations Questionnaire (MBSRQ), the Facial Appearance Sorting Test (FAST), the Breast Chest Ratings Scale (BCRS), the Derriford Scale (DASS59), the Health Utilities Index (HUI), and the EuroQol (EQ-5D).\textsuperscript{253}

### ADJUNCTIVE SURGERY

#### Jowls

Jowls are best corrected with a facelift cheek advancement, particularly one of the SMAS–platysma rotation methods. Partial excision of the buccal fat pad of Bichat is possible either through the facelift incision\textsuperscript{257,258} or intraorally.\textsuperscript{259}

#### Nasolabial Folds

The nasolabial contour is more difficult to manage than labiomental furrows or jowls. Millard et al.\textsuperscript{260,261} recommended extended nasolabial lipectomy and reported maintenance of improvement beyond the 6-month follow-up. The authors stated that the skin tension across the fold might lessen but that the fat does not come back.

A similar philosophy of fat removal was espoused by Ellenbogen et al.\textsuperscript{262} who use curettage in preference to excision, and by Rudkin and Miller.\textsuperscript{263} Arrunátegui\textsuperscript{264} described percutaneous layering of the redundant cheek fat across the nasolabial fold and into the upper lip to blunt the depth of the fold.

Barton\textsuperscript{110−112} and Hamra\textsuperscript{192} independently reported mobilization of the redundant, ptotic cheek fat on the undersurface of the resuspended cheek flap. By releasing the investing fascia and
moving the plane of dissection superficial to the SMAS at the level of the belly of the zygomaticus major muscle (Fig. 12), the anterior cheek skin can be placed under sufficient tension to stretch out the nasolabial fold. A technique of surgical release of the attachments at the depth of the nasolabial fold and secondary filling with fat grafts was independently proposed by Loeb and Guyuron and Michelow and subsequently by Hwang et al. Guyuron and Michelow noted good to excellent results in the nasolabial fold in 83% (29 of 35 patients) with this method. A similar experience was reported by Nicolle et al. The indications, technique, and results of aesthetic correction of the nasolabial fold with Gore-Tex foam were presented in articles by Mole, Artz and Dinner, Schoenrock and Chernoff, and Lassus. Malar Enhancement

The ideal face has prominent zygomatic bodies (“high cheekbones”) that crest over subtle hollows in the buccal area. The aim of aesthetic surgery usually is to accentuate the zygomatic body.

Malar augmentation with autogenous tissues during rhytidectomy typically entails resuspension of the ptotic malar fat pad or folding of the redundant upper SMAS on itself. When only moderate lift is necessary, it is possible to mobilize the cheek pad on the undersurface of the skin flap. When a great deal of upward displacement is needed and the pad is prominent, direct repositioning of the malar fat is advocated.

Owles relocated the malar fat pad upward and sutured it to the subcutaneous fascia at the lateral malar eminence. Barton and Kenkel described direct suture repositioning of the pad without undermining.

Sasaki and Cohen and Keller et al. advocated percutaneous cable sutures to elevate the malar mound. Yousif et al. described the suspension of the mid-face with either tendon, fascia, or Gortex and anchoring the cheek mass to the lateral orbital rim. Saylan attempted to elevate the mid-face by purse-string placation of the SMAS and fixation to the zygomatic bone. This method was modified by Verpaele et al. as the third suture in the MACS lift, anchored at the lateral orbital rim, and is used to elevate the malar region and mid-face.

Byrd and Andochick suspended the pad to the deep temporal fascia through a temporal supraperiosteal approach. May et al. preferred subperiosteal advancement of the cheek through a lower blepharoplasty incision at the time of alloplastic augmentation of the zygoma.

Hester et al. designed a procedure for direct suspension of the cheek mass to the temporal fascia at its insertion near the lateral orbital rim. He extended the transblepharoplasty, subperiosteal dissection into an approach to the lower lid and mid-face, noting that skin laxity is more pronounced in the medial face than laterally, and sutured the cheek-flap complex to the deep temporalis fascia (Fig. 20).

A 5-year follow-up of 757 patients who underwent this procedure revealed a 19% complication rate and a 9% reoperation rate. The authors modified both the extent of dissection and the use of lateral canthoplasty. Often, the entrance point for the subperiosteal malar dissection is closer to the lateral orbit or temple, with minimal lower lid dissection. Formal canthoplasty is reserved for selected high-risk cases.

Hester et al. focused on elevation of the mid-face and treatment of the lower eyelid complications. Their studies led to improved results in both the mid-face and the eyelid. Several authors have expanded on the work conducted by Hester et al. in efforts to isolate and elevate the mid-face alone or in combination with other maneuvers. Paul suggested a modification of the Hester technique in which a periosteal hinge flap based along the orbital rim is used to anchor the elevated malar periosteum to further support
the central facial lift. The price of these expected benefits is a high learning curve for the surgeon.

Gunter and Hackney\textsuperscript{293} reported the results achieved in 60 patients with a simplified modification of the Hester subperiosteal cheek lift. Another modification uses a trans-malar route in preference to a transblepharoplasty incision.\textsuperscript{294}

A number of rhytidectomy surgeons have focused their efforts on the drooping orbicularis oculi muscle. Furnas\textsuperscript{295} paid particular attention to the orbicularis oculi and the sagging of the muscle that occurs with age.

Hamra\textsuperscript{296} recognized the importance of surgically relocating the orbicularis during rhytidectomy and included a suborbicularis and malar dissection, arcus marginalis release, and superomedial repositioning of the orbicularis as part of his composite rhytidectomy. He thought that dissection in the supraperiosteal plane beneath the orbicularis and zygomatic muscles allowed for more elevation of the lower lid and malar tissues.\textsuperscript{297,298} Other authors\textsuperscript{229,283,299,300} recommended correction of the ptotic orbicularis oculi to various degrees and by different techniques.

Independent anatomic studies conducted by Pessa and Garza\textsuperscript{301} and Kikkawa et al.\textsuperscript{302} uncovered a malar septum thought to be the basis of malar mounds and malar edema. Osseous connections between the lower orbicularis and the zygoma form an oblique downward and outward fusion plane over which the redundant muscle tends to shelve. The authors suggested that adequate release of the malar septum might be necessary to properly smooth the lower orbital and malar soft tissues.

Mendelson et al.\textsuperscript{303} dissected cadavers to more accurately define the mid-face anatomy and noted a previously unrecognized glide plane above the zygoma. “The space functions to allow mobility of the orbicularis oculi, where it overlies the zygoma and the origins of the elevator muscles to the upper lip. The space is a cleft between the sub-orbicularis oculi fat and the preperiosteal fat and is lined by a fine membrane. The anatomic boundaries are clearly defined by retaining ligaments, which correlate with the triangularity of the space.”

Terino\textsuperscript{304} presented the principles of alloplastic malar augmentation. Silastic implants (Dow Corning, Midland, MI)\textsuperscript{304−306} and hydroxylapatite\textsuperscript{307} have been used for the purpose of enhancing the malar area.\textsuperscript{308,309}

**Defining the Jaw Line**

Giampapa and Di Bernardo\textsuperscript{310} described a submandibular suture sling to accentuate the mandibular border and minimize a ptotic
submandibular gland. A similar procedure was described by Fuente del Campo. In special situations, these sutures can be useful, but one must remember that tissues shift from recumbent on the operating table to vertical in active life. The success of these slings depends on the exact tension placed on the sutures, a matter of judgment and experience with the technique.

Other clinicians have described the use of a polytetrafluoroethylene cervical sling for improving neck contour. The reader is again cautioned regarding the use of permanent materials that are immobile and using them to hold normally animated tissues in a static position under tension. Long-term results are still needed to adequately evaluate this type of technique.

Several authors address the submandibular gland or the digastric muscles in an effort to rejuvenate the neck and jaw line, but these techniques have not gained wide acceptance among rhytidectomy surgeons. Guyuron et al. described a technique for submandibular gland suspension without removal. Baker questioned the prudence of submandibular gland resection and digastric muscle resection and presented a large series with long-term follow-up.

Labbé et al. used a platysma suspension technique that sutures the free edge of the platysma muscle and fixes it to the tissue that was described by Loré fascia. The method leads to a well-defined anterior triangle of the neck without the need for extensive undermining of the platysma muscle (Fig. 21). Serra-Renom et al. modified the lateral SMASectomy described by Baker by preserving the SMAS flap and using it as an inferiorly based tongue to enhance the definition of the mandible and jaw line. The SMAS flap is rotated and transposed to the mastoid (Fig. 22).

![Figure 21. Left, Stitch in platysma muscle and its fixation to fascia as described by Loré. Right, Effect on anterior triangle of neck. Inset, Purse stitch. (Reprinted with permission from Labbé et al.)](image-url)
Shortening the Scar

Another recent trend in rhytidectomy consists of shortening the postauricular scar to minimize the telltale signs of surgery. This is especially important in skin-based facelifts, for which tension is placed on the mastoid skin closure and hypertrophic scars can mar otherwise pleasing results. Little suggested placing the posterior “dog ear” high in the scalp above and behind the ear, rather than posteriorly over the mastoid. The same technique was subsequently described by Marchac et al. as the vertical U-incision. Various authors try to limit the postauricular scar whenever possible. In patients with minimal neck excess, the postauricular incision can be eliminated altogether.

Baker presented an algorithm for evaluating candidates for a short scar facelift. The type I ideal candidate is age early to late 40s, has good cervical skin elasticity, and presents with primarily facial aging, early jowls, and slight cervical skin laxity. The type II good candidate is age late 40s to early 50s, has moderate jowls, moderate cervical skin laxity, and some submental or submandibular fat without active platysma bands. The type III fair candidate is age late 50s to early 70s, has significant jowls, moderate cervical skin laxity, submental and submandibular fat, and significant platysma bands on animation. A type III patient requires a submental incision with platysma approximation in addition to dog ear removal in the retroauricular sulcus. The type IV candidate is age 60s or 70s and presents with significant jowls, poor cervical skin elasticity, skin folds below the cricoid with deep cervical creases, platysma bands, and submental and submandibular fat. A type IV patient might require extension of the retroauricular incision.

The advantages and disadvantages of minimal incision rhytidectomy are presented in Table 1.

Buccal Fat Pad

Pseudoherniation or prominence of the buccal fat pad (Bichat fat pad) can cause the appearance of facial fullness. In well-selected candidates, buccal fat pad excision can be performed to
improve facial contour and recreate a more angular appearing face with a mid-facial “cheek hollow.” Matarasso recommended using an intra-oral approach with conservative resection (Fig. 23).

Correction of the Aging Lip
Gonzalez-Ulloa in 1975, first directed our attention to age-related lengthening of the upper lip. Aging changes in the lip manifest in three ways: 1) longer distance between the columellar base and upper lip vermilion border, 2) less exposed vermilion (“thin lips”), and 3) relative loss of vermilion bulk (“pout”).

Excessive skin length between the nose and the lip vermilion border can be corrected by removing skin either from the base of the nose or from the vermilion border. Removal of skin along the alar and columellar bases was first suggested by Cardoso and Sperli and subsequently adopted by Rozner and Isaacs and later by Austin and Weston. The redundant lip skin is excised along the nostril sills and columellar base, emphasizing the points at the upper end of the philtral crest (Fig. 24). Overcorrection is necessary considering that secondary drop is inevitable. For patients with very broad upper lips, Austin recommended secondary skin excision in vertical-wedge fashion.

Several authors proposed removing the excess skin at the level of the vermilion. The main advantage of the vermilion advancement technique is the ability to directly and precisely position the Cupid’s bow. Disadvantages are the visible scar that is left on the lip margin and possible obliteration of the natural “white line.”

Correction of the thinning vermilion has been more difficult. Injections of bovine collagen and fat have yielded only temporary and somewhat lumpy results. Perhaps the most practical method of adding bulk tissue to the lip vermilion is by autogenous dermis grafts. This technique was described by Kesselring, who suggested it should be performed with concomitant vermilion advancement. Rohrich et al. described the use of acellular allogeneic dermis (AlloDerm; Life Cell Corporation, Branchburg, NJ) for lip augmentation with acceptable short-term results.

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
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<tr>
<td>Requires less dissection</td>
<td>Requires more vertical skin lift</td>
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<tr>
<td>Requires a less invasive procedure</td>
<td>Can make it difficult to fit in dog ears in temporal and earlobe areas</td>
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<tr>
<td>Is associated with less scarring</td>
<td>Requires time for temporal hairline scar to smooth</td>
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<tr>
<td>Avoids posterior hairline distortion</td>
<td>Requires time for retro earlobe scar to smooth</td>
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<tr>
<td>Makes for easier hematoma evacuation</td>
<td>Occasionally causes skin fold at base of earlobe</td>
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<tr>
<td>Limits neck exposure</td>
<td>Is not applicable to patients with severe cervical laxity</td>
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Some patients show ptosis of the chin mass as a manifestation of the aging diathesis. The resultant deformity is commonly known as a “witch’s chin” and is characterized by a prominent submental crease and a soft-tissue mass that hangs below the lower mandibular border.\(^{342}\)

A number of methods have been suggested for correction of the ptotic chin, and the methods were thoroughly reviewed by Feldman.\(^{342}\) The author reported a preference for direct excision of the redundant skin and subcutaneous mass. Alternatively, the mental mass can be resuspended through an intraoral incision with mobilization of the muscle-skin complex.\(^{343}\) This approach returns the ptotic chin mass to its original position by physiological means but might be more prone to relapse than superficial contouring.

de la Torre\(^ {344}\) described the use of a minimally invasive U-stitch to elevate the ptotic chin mass. The benefits can be short-lived.\(^ {345}\)

The most effective technique involves resuspension of the chin mass and insertion of a chin implant, which fills the redundant and ptotic...
tissue. Cutaneous dissection with release of the mental crease and retaining ligaments is an integral part of any redraping procedure.

**Suction Lipectomy**

Suction-assisted lipectomy (SAL) has been suggested as an adjunct to rhytidectomy for redraping the skin and subcutaneous tissues in various areas of the face and neck. When combined with rhytidectomy, suction can be applied either percutaneously before elevating the skin flaps or under direct vision through an open approach. The blunt SAL technique succeeds in defatting without detaching the skin and is safer than the sharp technique regarding the facial nerve and its branches.

The early enthusiasm for suction lipectomy in the cheeks has been tempered by reported problems with waviness and streaking of the subcutaneous tissues that become evident postoperatively and mar the results. In addition, concerns regarding the tendency of fat in the cheeks to atrophy over time have led to a conservative approach to fat excision in the face, so that defatting along the preauricular, zygomatic, and mandibular body areas has lost favor.

Some surgeons still advocate SAL for smoothing the nasolabial folds and jowls and also if one chooses to decrease the volume of the buccal fat pad of Bichat. Cautious SAL can help refine the surgical results of a facelift procedure in the nasolabial folds but within limits: if the folds are very deep and redundant, direct excision remains the best approach.

Today, the main indication of suction lipectomy in rhytidectomy is for defatting the neck in the preplatysmal plane, where SAL is relatively simple and safe and can facilitate dissection of the skin flaps. Postoperative subcutaneous irregularities, which are prevalent in the cheeks after SAL, have not manifested in the neck. In contrast, suction deep to the platysma in the submental region has not been as problem free and the associated risks of bleeding and nerve injury are very real. It is anecdotally known that most surgeons prefer to use sharp dissection when entering the subplatysmal fat layers.

**Contour Augmentation**

Considering the current emphasis on the mid-face and restoring subcutaneous volume to the malar region, interest in injection and implantation methods to plump out these areas subtly and precisely has been renewed.

**Fat Injections**

Free transplantation of fatty tissue dates to 1950 and the work of Peer, who found only 50% survival of fat grafts. Since then, technical improvements have come into play, and today, autologous fat injections are an established part of facial aesthetic recontouring.

Guerrerosantos recounted a 10-year experience with 357 consecutive patients who underwent simultaneous rhytidectomy and lipoinjection to various facial recipient areas. In this article and in a later article encompassing 1936 cases of facial recontouring performed over 17 years, Guerrerosantos reported a high survival rate of fat autografts and few complications. The author offers the following tips:

- Fat grafts must be injected in small or moderate volumes at each treatment.
- The best results occur when fat grafts are injected subfascially or into the muscles.
- The fat injections must be deep, in several sites, deposited as drops or thin rolls.
- The injected areas must be thoroughly massaged to ensure adequate dispersal of the fat.

A similar enthusiasm for autologous fat transplantation in facial sculpting was expressed by Coleman, Ellenbogen, and Trepsat. For tear trough and other peri-ocular deformities, Ellenbogen reported a preference for obtaining
the fat through an incision, cutting it into “pearls” or small almonds, and placing the grafts subcutaneously, aiming for slight overcorrection. Lipoinjections are used exclusively in the lips, nasolabial folds, chin, jawline, labiomandibular folds, and zygomas. In addition to free fat micrograft injection, Little also recommended the classic dermal fat grafts for adding volume to the mid-face. Rohrich et al. reported injecting directly into the deep medial fat compartment. Injection into that compartment increases anterior projection, diminishes the nasolabial fold, corrects the V-deformity, and recreates a youthful cheek with natural boundaries.

Kaufman et al. surveyed 650 randomly selected members of the American Society for Aesthetic Plastic Surgery. Analysis of the data revealed the prevalence of autologous fat transfer, the most commonly used techniques for harvest and injection, and the perceived outcome. The authors summarized the findings as follows:

“(1) autologous fat transfer is a relatively common procedure (57 percent perform >10 annually), but few perform it in high volume (only 23 percent perform >30 annually);

(2) techniques for harvest, preparation, and injection rarely deviate from methods discussed in the literature (microcannula, 54 percent; centrifugation, 75 percent; injection in nasolabial fold > lips > nasojugal folds);

(3) most physicians believe that at least some graft survival is clinically evident (93 percent);

(4) patients are pleased with the short-term results (good to excellent, 84 percent), despite a lower rate of long-term patient satisfaction (fair to good, 80 percent).”

The authors concluded, “Currently, plastic surgeons across the country report a uniformity of autologous fat grafting techniques with acceptable patient satisfaction.”

**Soft-Tissue Fillers and Injectables**

In the last few years, new soft-tissue contouring agents such as hyaluronic acid have spurred a tremendous increase in the use of non-autologous fillers in facial rejuvenation, alone or in combination with rhytidectomy. This topic is discussed in the “Injectables” issue of Selected Readings in Plastic Surgery.

**FACELIFT IN MEN**

Modifications of the facelift procedure in men usually concern incision placement relative to the male hair growth pattern. Baker et al. and Connell noted that the incision for both men and women should be the same, whereas Baker and Gordon and Sturman recommended a hairline incision for men. Cremona et al. suggested placing the incision at the apex of the tragus and excising the glabrous skin. The edge of the cheek flap in the preauricular area is then depilated by undercutting and cautering the hair follicles.

Baker et al. continue the preauricular incision along the coronal line into the temporal scalp, whereas Baker and Gordon and others prefer a transverse incision at approximately the level of the zygoma with mostly upward advancement of the skin flap. This supposedly spares the temporoparietal area that might later be exposed by balding and can be joined to the lateral extension of a brow incision to correct brow ptosis, as illustrated by Gurdin and Carlin.

**NECK**

A number of classifications have been suggested for submental deformities, but it is perhaps easier to think of them in terms of the individual components: skin redundancy, platysmal separation and banding, and excessive cervical fat. These superficial soft-tissue elements must then be considered against the backdrop of the underlying...
musculoskeletal architecture: neck length, position of the hyoid bone in relation to neck muscles (cervicomental angle),\textsuperscript{384,385} and projection of the mandible.

Ellenbogen and Karlin\textsuperscript{384} list five criteria of a youthful neck:

- a distinct inferior mandibular border
- a subhyoid depression
- a visible thyroid cartilage
- a visible anterior sternocleidomastoid muscle border
- a sternocleidomastoid muscle–submental plane angle of 90 degrees (cervicomental angle 105–120 degrees)

**Long Thin Neck and Platysma Slings**

The classic Skoog facelift advances the cheek and cervical tissues as a single unit. The problem is that the skin in the lower face and neck is typically more redundant than in the rest of the face, and with the straight advancement of the Skoog technique, tissue pull in the upper face is of the same magnitude as that in the lower face. To overcome this disadvantage and increase the effect of lifting on the neck, several modifications have been proposed that rotate the cheek and neck tissues around an axis near the zygoma after dividing the platysma and suspending it like a “sling.” Some of the suggested variations are as follows:

- resection of the medial platysmal bands with plication and horizontal incision\textsuperscript{386–388}
- division and suspension of the posterior one-half of the platysma\textsuperscript{389}
- partial division of the platysma at its medial and lateral borders\textsuperscript{390,391}
- division and suspension of the entire platysma\textsuperscript{347,392}
- anterior “corset” plication\textsuperscript{324,393}

Detailed descriptions of the various platysma rotation techniques were presented by Hamra,\textsuperscript{350} Lemmon,\textsuperscript{394} Aston,\textsuperscript{387} Kaye,\textsuperscript{391} Connell,\textsuperscript{347} Owsley,\textsuperscript{395} and McKinney.\textsuperscript{396,397} All transect the platysma near the mid-cervical crease or at the level of the thyroid cartilage, and most combine platysma division with submental plication and cervical defatting. Platysma sling procedures suffer from several disadvantages, including incomplete suspension of the submental area, unveiling and ptosis of the submandibular glands, and occasional prominence of the retracted cut edge of the platysma. Whether platysma suspension accomplishes a better result has never been objectively shown, but it seems that most surgeons think that it does.

The characteristic “turkey gobbler” deformity is caused by prominent bands of platysma and redundant skin. Correction of the vertical submental bands initially centered on standard skin-lengthening techniques, such as T-, Z-, S-, and W-plasties,\textsuperscript{398} until Adamson et al.\textsuperscript{162} in 1964, identified the medial edges of the platysma muscle as the cause of the deformity; the skin was only a secondary factor. The authors recommended conservative skin excision or incision and then imbrication of the medial borders of the platysma to mimic submental decussation and produce a muscular sling. Weisman\textsuperscript{399} suggested Z-plasty of the medial edge of the platysma, and Millard et al.\textsuperscript{386} advocated excision of the redundant muscle anteriorly.

Since its conception, the platysmal sling has become the preferred method of correction for the turkey gobbler deformity. Some authors now recommend submental skin incision without excision, defatting if necessary, and suture plication of the muscle edges.\textsuperscript{257,389,392,400} Because approximation of the anterior platysmal bands in the midline can increase banding of the lower platysma below the level of the hyoid, a frequent part of the technique is either excision or incision of the anterior edge of the muscle.\textsuperscript{347,350,387,389–392,394}

Feldman\textsuperscript{393} recommended correcting the cervicomental angle purely by anterior traction,
avoiding the combined anterior-superior suspension and many of the problems with ridging and irregularity that develop along cut platysmal borders. A double-layered permanent suture is carried from the submandibular area down to the thyroid and back in corset fashion (Fig. 25).

The current trend in cervical contouring is toward increasingly aggressive anterior midline platysmal plication. Many surgeons now think that a better result can be achieved by direct tightening of the neck at the point of prominence than by distant pull from the sides.

**Short Fat Neck**
Characterized by a double chin, the short fat neck deformity is the result of excessive deposition of adipose tissue in the cervical and submental areas. Ellenbogen and Karlin reviewed the various techniques available for correction of the double chin deformity and the procedure selection process.

Marino et al. stressed the importance of the position of the hyoid bone in patients with an obtuse cervicomental angle. If the hyoid bone is in its normal (high) position, submental lipectomy can be expected to markedly improve the deformity, but if the hyoid is low-lying, submental lipectomy will only produce minimal correction. Many surgeons combine cervical defatting with platysma-tightening procedures to additionally define the neck of patients with obtuse cervicomental angles. Singer reported extending the indications for the procedure to include young patients with fatty necks.

Millard et al. advocated defatting the entire cervical area in a preplatysmal plane. Because the marginal mandibular branch of the facial nerve runs consistently deep to the platysma, the procedure is relatively safe as long as the dissection is kept superficial to the muscle.

Robbins and Shaw described their experience with en bloc cervical lipectomy.

**Figure 25.** Technique of corset platysmaplasty. A, Surface of platysma is cleared of fat. If submental platysma is decussated, narrow midline strip of muscle is excised to allow removal of subplatysmal fat. B, When suture reaches point two to three fingerbreadths above suprasternal notch, it reverses direction and runs upward to chin. C, Completed platysma muscle corset. Neck contour can be refined with sling sutures from medial to lateral platysma just below jawline or a few plication sutures from lateral platysma to sternomastoid fascia. (Reprinted with permission from Feldman.)
Dissection is carried out in the superficial subcutaneous plane, while a second dissection plane is established along the external surface of the investing fascia of the platysma. The entire preplatysmal fatty mass in the neck can be removed as one continuous specimen. The authors claimed advantages of more even dissection and less trauma than if suction lipectomy were performed.

For patients who have particularly obtuse neck angles and low-lying hyoid bones, Guyuron suggested submental myotomy of the digastric, geniohyoid, and mylohyoid muscles to allow posterosuperior displacement of the cervicomental contour. Although this somewhat aggressive procedure has not been universally accepted, the surgical logic underlying this concept merits consideration.

Finally, some patients with fatty necks have persistent prominence of ptotic submandibular glands below each mandibular body. de Pina and Quinta suggested partial or complete resection of the submandibular glands, usually through direct incision. Because of the potential risk to the mandibular branch of the facial nerve and the frequent need for secondary external incisions, this procedure has not gained wide popularity.

**COMPLICATIONS**

**Hematoma**

Several large studies have shown an overall hematoma rate of approximately 4% in female patients, with hematoma after rhytidectomy occurring twice as commonly in men as in women, averaging 8% in two large series of male patients. Table 2 lists the overall incidence of hematoma in association with facelift.

In 1994, Rees et al. reported a series of 1236 consecutive facelifts performed by 50 surgeons at the Manhattan Eye, Ear & Throat Hospital during a 2-year period. The overall incidence of hematoma encountered by surgeons who performed more than 50 facelifts in the study ranged from 0 to 3.83%. A high incidence of hematoma was associated with preoperative systolic blood pressure (>150 mmHg). Hematomas were also more likely to occur in patients whose intraoperative blood pressures were significantly below normal and who later rebounded to hypertensive levels after the absorption of adrenalin-containing local anesthetic solution. Seify et al. identified the role of elevated systolic blood pressure in the etiology of hematoma. Baker et al. reported a decline in the incidence of hematomas in men undergoing facelifts over a 30-year period after the initiation of a strict and aggressive perioperative blood pressure regimen.

Grover et al. evaluated 1078 patients and identified anterior platysmaplasty, male gender, aspirin and nonsteroidal antiinflammatory intake, and smoking as resulting in a statistically significant increase in the rate of postoperative hematoma. Jones and Grover retrospectively reviewed 990 patients who underwent facelift with ancillary procedures and found no reduction in hematoma rate despite using postoperative compression dressings, surgical drains, fibrin glue, or the tumescent technique for dissection. The authors concluded that meticulous intraoperative hemostasis and adequate control of postoperative blood pressure are important components of hematoma prevention.

Palaia et al. argued for the use of desmopressin acetate (1-desamino-8-D-arginine vasopressin) in reducing both ecchymosis and micro-hematomas after facelift.

Several authors have investigated the efficacy of ancillary procedures in reducing hematoma rates, with conflicting conclusions. Oliver et al., Man et al., Fezza et al., Powell et al., and Marchac and Greensmith suggested using tissue sealants such as fibrin glue and autologous platelet gel to decrease postoperative bleeding, edema, and ecchymosis postoperatively. A meta-analysis conducted by Por et al. investigated the use of tissue sealants with rhytidectomy. The pooled results showed a trend toward reduction in
### Table 2
Hematoma after Facelift

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Patients</th>
<th>No. of Cases of Hematoma (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Subcutaneous</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baker and Gordon, 1967(^{408})</td>
<td>300</td>
<td>1 (0.3)</td>
</tr>
<tr>
<td>Conway, 1970(^{174})</td>
<td>325</td>
<td>21 (6.5)</td>
</tr>
<tr>
<td>Pitanguy et al., 1971(^{609})</td>
<td>1600</td>
<td>89 (5.5)</td>
</tr>
<tr>
<td>McGregor and Greenberg, 1972(^{426})</td>
<td>527</td>
<td>42 (8.1)</td>
</tr>
<tr>
<td>McDowell, 1972(^{110})</td>
<td>105</td>
<td>3 (2.9)</td>
</tr>
<tr>
<td>Stark, 1972(^{411})</td>
<td>100</td>
<td>3 (3.0)</td>
</tr>
<tr>
<td>Webster, 1972(^{412})</td>
<td>221</td>
<td>2 (0.9)</td>
</tr>
<tr>
<td>Gleason, 1973(^{413})</td>
<td>102</td>
<td>1 (1.0)</td>
</tr>
<tr>
<td>Morgan, 1973(^{414})</td>
<td>40</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Pitanguy et al., 1973(^{607})</td>
<td>52</td>
<td>4 (7.7)</td>
</tr>
<tr>
<td>Rees et al., 1973(^{415})</td>
<td>806</td>
<td>23 (2.9)</td>
</tr>
<tr>
<td>Barker, 1974(^{416})</td>
<td>151</td>
<td>2 (1.3)</td>
</tr>
<tr>
<td>Stark, 1977(^{177})</td>
<td>500</td>
<td>13 (2.6)</td>
</tr>
<tr>
<td>Leist et al., 1977(^{417})</td>
<td>324</td>
<td>19 (5.9)</td>
</tr>
<tr>
<td>Baker et al., 1977(^{418})</td>
<td>1500</td>
<td>46 (3.1)</td>
</tr>
<tr>
<td>Thompson and Ashley, 1978(^{419})</td>
<td>922</td>
<td>44 (4.8)</td>
</tr>
<tr>
<td>Baker, 1983(^{420})</td>
<td>9460</td>
<td>353 (3.8)</td>
</tr>
<tr>
<td>Cohen and Webster, 1983(^{421})</td>
<td>149</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17184</td>
<td>667 (3.9)</td>
</tr>
<tr>
<td><strong>SubSMAS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemmon and Hamra, 1980(^{189})</td>
<td>577</td>
<td>5 (0.8)</td>
</tr>
<tr>
<td>Hugo, 1980(^{402})</td>
<td>82</td>
<td>2 (2.4)</td>
</tr>
<tr>
<td>Matsunaga, 1981(^{422})</td>
<td>427</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Owsley, 1983(^{395})</td>
<td>460</td>
<td>6 (1.3)</td>
</tr>
<tr>
<td>Lemmon, 1983(^{394})</td>
<td>1449</td>
<td>8 (0.5)</td>
</tr>
<tr>
<td>Shirakabe, 1988(^{423})</td>
<td>738</td>
<td>9 (1.2)</td>
</tr>
<tr>
<td>Grover and Jones, 2001(^{424})</td>
<td>1078</td>
<td>45 (4.2)</td>
</tr>
<tr>
<td>Jones and Grover, 2004(^{425})</td>
<td>678</td>
<td>30 (4.4)</td>
</tr>
<tr>
<td>Ullmann and Levy, 2004(^{427})</td>
<td>3580</td>
<td>17 (0.47)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9069</td>
<td>123 (1.7)</td>
</tr>
</tbody>
</table>
postoperative drainage at 24 hours and decreased ecchymosis. This was confirmed by non-controlled prospective studies of the use of fibrin glue\textsuperscript{438} and platelet gel sealant.\textsuperscript{439} Both of these studies show decreased wound drainage and ecchymosis. No effect on hematoma rate was found.\textsuperscript{438} Jones et al.\textsuperscript{440} conducted a randomized controlled trial on the use of surgical drainage. Although drains did not decrease the rate of hematoma or edema, they produced a significant reduction in postoperative bruising.

Nerve Injury
The buccal branch of the facial nerve is injured most often during rhytidectomy,\textsuperscript{426} even if subtle differences in animation go unreported because of overlapping neural territories in the upper lip. In contrast, injury to either the marginal mandibular or temporal ramus is more likely to be obvious and permanent because these branches overlap very little with other divisions of the facial nerve. The marginal mandibular branch usually suffers more trauma than the temporal branch during facelift flap dissection, and the resultant paralysis is particularly obvious in patients with a “full denture smile.”\textsuperscript{441} The marginal mandibular ramus can also incur damage with upward pulling on the superior platysma flap. Daane and Owsley\textsuperscript{442} noted perioral paresthesia in 1.7% of cases (34 of 2002 cases), with full recovery achieved in 3 weeks to 6 months in all patients.

It is clear that deeper dissection techniques cause more nerve injuries. Dissection near the facial nerve branches frequently creates a mild neurapraxia that resolves in several weeks. Of greater significance is the permanent nerve injuries associated with the classic subcutaneous dissections (Table 3).\textsuperscript{112,124,174,177,183,187,189,191,206,249,322,402,408,410,413,417−419,421−423,425−427}

Since the advent of platysmal slings, there has been a relative increase in “pseudoparalysis” of the lower lip. Transection of the mid-cervical platysma can sever the motor branches of cranial nerve VII to the remaining proximal platysma, which normally continues upward into the lower lip to join the depressor labii inferioris.

Lemmon\textsuperscript{394} discussed his experience with 1499 rhytidectomies and offered a detailed, candid appraisal of results, analyzing the changing frequency of problems with different types of procedures. Of special interest is the observation that during the period when the operators were doing subtotal excision of the platysma, the incidence of pseudoparalysis was 16.5% and permanent lower lip dysfunction occurred in 0.9%.

Baker and Conley\textsuperscript{124} reviewed the management of injuries to the great auricular nerve in their discussion of facial nerve injuries. Idiopathic trauma to the great auricular nerve can cause temporary loss of sensation of a portion of the ear, scalp, and face.

Pantaloni and Sullivan\textsuperscript{142} discussed the anatomic location of the lesser occipital nerve and technical considerations to prevent its injury during rhytidectomy. Mowlavi and Wilhelmi\textsuperscript{443} described the use of bony landmarks to identify the lateral border of the zygomaticus major muscle, which is important in extended SMAS facelifts.

Skin Dehiscence
Skin slough is usually preceded by hematoma or infection and occurs most often in the retroauricular region. The incidence of significant skin slough after rhytidectomy is summarized in Table 4.\textsuperscript{174,177,189,394,395,402,407,408,410,413,417−419,421−423,425−427}

The adverse effect of cigarette smoking on skin flaps has been documented experimentally\textsuperscript{444−447} and clinically, yet the mechanism by which nicotine predisposes to skin flap necrosis is still speculative.\textsuperscript{448} With each cigarette that is smoked, approximately 2 to 3 mg of nicotine and 20 to 30 mL of carbon monoxide are inhaled.\textsuperscript{447} Nicotine is known to trigger the release of epinephrine, with subsequent constriction of the microcapillary bed.\textsuperscript{449} Nicotine is also associated with increased platelet adhesiveness, causing micro-clots and decreased
microperfusion of tissues. In addition, nicotine has a detrimental effect on collagen solubility and temporarily retards wound healing during postoperative days 6 through 10.

Carbon monoxide, another significant component of cigarette smoke, contributes to reduced oxygen delivery to the peripheral tissues when combined with hemoglobin. The affinity of carbon monoxide for hemoglobin binding is 200 times that of oxygen. Hydrogen cyanide from cigarette smoke inhibits the synthesis of enzymes necessary for oxidative metabolism and oxygen transport at the cellular level.

Only scant histological data are available for the effects of cigarette smoking on human tissues. Riefkohl et al. noted increased small vessel occlusive disease in rhytidectomy patients who had history of cigarette smoking, which correlated with a greater incidence of skin slough after surgery. Rees et al. documented impaired cutaneous circulation

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Patients</th>
<th>No. of Cases of Palsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subcutaneous</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baker and Gordon, 1967</td>
<td>300</td>
<td>2</td>
</tr>
<tr>
<td>Conway, 1970</td>
<td>325</td>
<td>2</td>
</tr>
<tr>
<td>McDowell, 1972</td>
<td>105</td>
<td>1</td>
</tr>
<tr>
<td>Gleason, 1973</td>
<td>102</td>
<td>0</td>
</tr>
<tr>
<td>Baker et al., 1977</td>
<td>1500</td>
<td>1</td>
</tr>
<tr>
<td>Leist et al., 1977</td>
<td>324</td>
<td>3</td>
</tr>
<tr>
<td>Stark, 1977</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>Thompson and Ashley, 1978</td>
<td>922</td>
<td>1</td>
</tr>
<tr>
<td>Baker and Conley, 1979</td>
<td>6500*</td>
<td>7</td>
</tr>
<tr>
<td>Duffy and Friedland, 1994</td>
<td>750</td>
<td>4</td>
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<td>Robbins et al., 1995</td>
<td>226</td>
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</tr>
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<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Patients</th>
<th>No. of Cases of Palsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>SubSMAS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hugo, 1980</td>
<td>82</td>
<td>0</td>
</tr>
<tr>
<td>Lemmon and Hamra, 1980</td>
<td>577</td>
<td>0</td>
</tr>
<tr>
<td>Shirakabe, 1988</td>
<td>738</td>
<td>0</td>
</tr>
<tr>
<td>Hamra, 1990</td>
<td>403</td>
<td>0</td>
</tr>
<tr>
<td>Barton, 1992</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>Ivy et al., 1996</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>Hagerty and Scioscia, 1998</td>
<td>89</td>
<td>0</td>
</tr>
<tr>
<td>Little, 1999</td>
<td>129</td>
<td>0</td>
</tr>
</tbody>
</table>

*Literature review.
in patients who smoked. Again, this manifested clinically as a significantly higher incidence of skin flap necrosis after facelift. The minimum period of abstinence from tobacco that is necessary to avert skin slough has not yet been determined.

### Alopecia

Factors predisposing to hair loss after facelift include variation in placement of the temporal incision, depth of undermining, and tension of the closure. The reported incidence of alopecia in rhytidectomy is presented in Table 5.174,177,395,402,407,410,421−423,426,430 Alopecia or hairline distortion after rhytidectomy can be corrected with micro-grafts and mini-grafts.454−456

### Deep Vein Thrombosis and Thromboembolism

Reinisch et al.457 reviewed the incidence of deep vein thrombosis (DVT) and pulmonary embolism (PE) after facelift. They surveyed 273 members

| Table 4  
| Skin Slough after Facelift |
|---|---|---|
| Study | No. of Patients | No. of Cases of Slough (%) |
| **Subcutaneous** | | |
| Baker and Gordon, 1967 | 300 | 0 |
| Conway, 1970 | 325 | 1 (0.3) |
| McGregor and Greenberg, 1972 | 527 | 16 (3) |
| McDowell, 1972 | 105 | 1 (0.9) |
| Gleason, 1973 | 102 | 3 (2.9) |
| Pitanguy et al., 1973 | 52 | 0 |
| Stark, 1977 | 500 | 1 (0.2) |
| Leist et al., 1977 | 324 | 3 (0.9) |
| Baker et al., 1977 | 1500 | 17 (1.1) |
| Thompson and Ashley, 1978 | 922 | 131 (14.2) |
| Cohen and Webster, 1983 | 149 | 0 |
| **Total** | 4806 | 173 (3.6) |
| **SubSMAS** | | |
| Lemmon and Hamra, 1980 | 577 | 5 (0.8) |
| Hugo, 1980 | 82 | 2 (2.4) |
| Matsunaga, 1981 | 427 | 1 (0.2) |
| Owsley, 1983 | 460 | 0 |
| Lemmon, 1983 | 1449 | 0 |
| Shirakabe, 1988 | 738 | 7 (1) |
| Jones and Grover, 2004 | 678 | 15 (2.2) |
| Ullmann and Levy, 2004 | 3580 | 51 (1.4) |
| **Total** | 7991 | 81 (1) |
of the American Society of Aesthetic Plastic Surgery who performed 9937 rhytidectomies during the 12-month study period. Respondents reported 35 patients (0.35%) with DVT, 14 patients (0.14%) with PE, and one death (0.01%). The most important information gleaned from this study was knowledge of the risk factors for these complications. Patients who underwent facelifts while under general anesthesia and did not have intermittent compression devices applied during surgery were at significantly higher risk. Anti-thromboembolic disease stockings and/or elasticized bandage wraps alone were insufficient for preventing DVT and PE.

Durnig and Jungwirth\textsuperscript{458} examined a retrospective series on the use of low-molecular-weight heparin. The rate of postoperative bleeding was 16.2% in the heparin group versus 1.1% in the control group. No instances of symptomatic thromboembolic events were noted in either group. It should be noted that the authors performed the operations with the patients under neuroleptic sedation with compression stockings applied as prophylaxis. Stuzin\textsuperscript{459} questioned the role of low-molecular-weight heparin in rhytidectomy. He suggested that length of surgery, general anesthesia versus sedation, and use of intermittent compression are more important predictors of thromboembolic events.

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of Patients</th>
<th>No. of Cases of Alopecia (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conway, 1970\textsuperscript{174}</td>
<td>325</td>
<td>0</td>
</tr>
<tr>
<td>McGregor and Greenberg, 1972\textsuperscript{426}</td>
<td>527</td>
<td>15 (2.8)</td>
</tr>
<tr>
<td>McDowell, 1972\textsuperscript{410}</td>
<td>105</td>
<td>0</td>
</tr>
<tr>
<td>Pitanguy et al., 1973\textsuperscript{407}</td>
<td>52</td>
<td>1 (1.9)</td>
</tr>
<tr>
<td>Stark, 1977\textsuperscript{177}</td>
<td>500</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Leist et al., 1977\textsuperscript{417}</td>
<td>324</td>
<td>10 (3)</td>
</tr>
<tr>
<td>Cohen and Webster, 1983\textsuperscript{421}</td>
<td>149</td>
<td>2 (1.3)</td>
</tr>
<tr>
<td>Total</td>
<td>1982</td>
<td>29 (1.5)</td>
</tr>
<tr>
<td>Lemmon and Hamra, 1980\textsuperscript{189}</td>
<td>577</td>
<td>3 (0.5)</td>
</tr>
<tr>
<td>Hugo, 1980\textsuperscript{402}</td>
<td>82</td>
<td>0</td>
</tr>
<tr>
<td>Matsunaga, 1981\textsuperscript{422}</td>
<td>427</td>
<td>1 (0.2)</td>
</tr>
<tr>
<td>Owsley, 1983\textsuperscript{356}</td>
<td>460</td>
<td>10 (2.3)</td>
</tr>
<tr>
<td>Shirakabe, 1988\textsuperscript{421}</td>
<td>738</td>
<td>4 (0.5)</td>
</tr>
<tr>
<td>Jones and Grover, 2004\textsuperscript{430}</td>
<td>678</td>
<td>20 (2.9)</td>
</tr>
<tr>
<td>Total</td>
<td>2962</td>
<td>38 (1.3)</td>
</tr>
</tbody>
</table>
Hypertension
Elevated diastolic and, more importantly, systolic blood pressure during the perioperative period contributes to hematoma formation. Berner et al.\(^4\) noted occasional postoperative rebound hypertension after rhytidectomy and suggested prophylactic administration of 25 mg of chlorpromazine 1 h before completing the surgery and again 3 h postoperatively. This dose should be repeated at 4-h intervals for up to 24 h after surgery if the systolic blood pressure is >150 mmHg.

For patients with sustained intraoperative or postoperative hypertension, new antihypertensive agents offer more delicate and precise control of the blood pressure.\(^4\) Clonidine, a sympatholytic agent, can be administered in doses of 0.1 to 0.3 mg 1 h before surgery to patients who are prone to hypertension. Clonidine also comes in a transdermal patch in doses varying from 0.1 to 0.3 mg; the 0.2-mg patch is often useful when placed preoperatively. The maximum effect is not obtained until 6 to 8 h after administration, which coincides with the onset of postoperative adrenaline-induced hypertension. The maximum effect may last as long as 48 h, which is well past the risk period.

Nifedipine is no longer recommended because of idiosyncratic reactions in patients who are taking beta blockers. Labetalol hydrochloride can be used as an alternative in doses of 5 mg/mL administered in 1- to 2-mL boluses. Labetalol is a combined alpha and beta blocker that will lower the blood pressure for 1 to 2 h. The beta blocker esmolol (Brevibloc), in a dose of 2.5 g diluted in 150 to 500 mL of normal saline, is also useful as an intravenous drip to lower the blood pressure for a few minutes. Although these agents are gentler and easier to adjust than previously used drugs such as nitroprusside, all demand constant blood pressure monitoring.

Minor Complications
Baker\(^4\) reported the incidence of minor problems associated with rhytidectomy (Table 6). He and other authors\(^4\) have noted small hematomas, hypertrophic scars, pigmentation changes, infection, edema, earlobe traction deformity, chronic pain, and salivary cysts.

Along with the increasingly frequent sub-SMAS dissections in rhytidectomy have come sporadic reports of parotid injury and related dysfunction. Yu and Hamilton\(^4\) reported a case of Frey syndrome after facelift surgery with SMAS dissection. Wolf et al.\(^4\) added three cases of parotid fistula to the four cases found in the literature. McKinney et al.\(^4\) found that parotid fluid collections after rhytidectomy are more effectively controlled with transient suction drainage than with repeated aspirations.

LeRoy et al.\(^4\) retrospectively evaluated 6166 consecutive facelifts and focused on 11 infections requiring hospital readmission (a 0.18% incidence). Seven patients had abscesses that were shown by culture to be caused by Staphylococcus. Cultures obtained from patients with cellulitis (four patients) were either sterile or grew a number of organisms in addition to staphylococci. No correlation could be made between development of infection and patient medical history, perioperative antibiotics, surgical equipment, complexity of the surgical dissection, drains, or hematoma. Blackwell et al.\(^4\) described a case of spinal accessory nerve palsy after rhytidectomy with SMAS dissection and anterior platysma plication.
### Table 6
Minor Complications in Facelift

<table>
<thead>
<tr>
<th>Complication</th>
<th>Incidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small hematoma (2−20 cc)</td>
<td>Common (15%)</td>
</tr>
<tr>
<td>Ear lobe deformity</td>
<td>5%</td>
</tr>
<tr>
<td>Submental depression</td>
<td>5%</td>
</tr>
<tr>
<td>Sensory nerve injury (occipital, great auricular)</td>
<td>1−5%</td>
</tr>
<tr>
<td>Hypertrophic scar</td>
<td>1−4%</td>
</tr>
<tr>
<td>Hair loss</td>
<td>1−3%</td>
</tr>
<tr>
<td>Infection</td>
<td>Rare (1%)</td>
</tr>
<tr>
<td>Prolonged ecchymosis</td>
<td>Rare</td>
</tr>
<tr>
<td>Prolonged edema</td>
<td>Rare</td>
</tr>
</tbody>
</table>
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