Surgery of the Superficial Musculoaponeurotic System: Principles of Release, Vectors, and Fixation

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Surgery of the Superficial Musculoaponeurotic System: Principles of Release, Vectors, and Fixation

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The SMAS was described more than 25 years ago, yet its full potential in face-lift surgery has become appreciated only more recently. A reappraisal of the various aspects of SMAS surgery is now appropriate. These include aspects of its release from the deep fascia, the several considerations underlying the vectors of flap redistribution, and the rationale underlying the methods of flap fixation. These are unique, compared with the traditional considerations in subcutaneous face lifts and en bloc subperiosteal lifts. (*Plast. Reconstr. Surg.* 107: 1545, 2001.)

"*If you understand something in only one way, then you do not really understand it at all.*"
—Marvin Minsky, *Society of the Mind*, 1987

The essence of most rejuvenation surgery of the face and brow is to mobilize the lax and ptotic tissue (skin based flap with a varying depth of the underlying tissue) and then advance that flap to a somewhat higher position relative to the facial skeleton. The question of "preferred direction of lift" is still discussed, although current teaching favors a strong vertical lift for best correction. Of necessity, with limited access surgery, vertical traction is all that is possible.

The inclusion of the superficial musculoaponeurotic system (SMAS) has been the most fundamental change in technique since the beginning of face-lift surgery.[1,2] Face-lift surgery performed using the traditional subcutaneous technique has been based on well-established routines. When the SMAS became incorporated in the technique, although it provided a range of enhanced possibilities, it has been associated with some limitations and problems that have only gradually become understood.

Chief among these was that, although the basic anatomy of the SMAS (the deeper layer of the superficial fascia of the face) was well described at the outset, other most relevant anatomy was not. Particularly significant is the anatomy of the ligamentous attachments between the SMAS and the facial skeleton.[3–5] The sub-SMAS region of the medial cheek was considered to be a nearly impenetrable jungle. At that time, is was considered unsafe to dissect beneath the superficial fascia of the cheek, other than over the buccal space where dissection is less difficult.[1] Complicating matters is that the SMAS incorporates the muscles of facial expression. Normal function of these muscles can be disturbed by SMAS surgery. This complication may arise from nerve damage occurring during the dissection or from abnormal pulling or distorted movements as a result of incomplete dissection or incorrect fixation.

In the 25 years since the introduction of the superficial fascia into face-lift surgery, there has accumulated a sufficient body of experience and of detailed anatomic knowledge to reflect on the basic principles of SMAS surgery. These explain some of the difficulties that have been associated with the procedure in the past. It becomes apparent that the principles that were so well established for traditional face-lift surgery were not necessarily sufficient for the different requirements with surgery of the SMAS.

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The discussion that follows is a synthesis of empiric observation and established fact. It covers the related topics of extent of release required, vectors of lift, and principles of fixation.

RELEASE

The matter of "the extent of surgical release required" continues to engage the mind of aesthetic plastic surgeons. When face lifts are performed at the subcutaneous and subperiosteal levels, this is a relatively simple matter, as these face-lift flaps have a relatively uniform attachment to the deeper layer. Considerations of surgical release are more complex in SMAS flap surgery due to the nature of the attachment of the SMAS to the underlying periosteum and deep fascia. There are specific areas of strong ligamentous fixation that require definitive surgical release and that contrast with intervening areas of loose adherence, which separate readily, such as the buccal and prezygomatic spaces. Those techniques of SMAS surgery that involve plication or imbrication of the exposed surface of the SMAS[6–8] are fundamentally different from SMAS flap surgery, as they do not involve mobilization of a SMAS flap with the attendant surgical release of the areas of ligamentous fixation.

The effect of complete surgical release of the deep ligamentous fixation of the SMAS in the vicinity of the area requiring correction is to reduce the resistance of the tissues so that when traction is applied to this area the flap readily moves. Movement ceases when a new equilibrium is reached, i.e., when the laxity has been taken up and the resistance of the tissues again increases to equal the tension force applied (Fig. 1, *left* and *second from left*).

Accordingly, the extent of undermining required in SMAS flap surgery is the minimal amount necessary to enable a tension-free repositioning sufficient to fully correct the area of redundancy. If the SMAS flap is not completely released, the resistance of the tissues to the traction force applied requires the application of a greater force. This increased force, although not sufficient to overcome the ligamentous resistance, may result in a stretching of those tissues of the flap between the force point (at which the force is applied) and the point of ligamentous resistance (Fig. 1, *second from right*). At best, stretching may achieve a temporary correction of laxity, but only while the tension force persists. Although it is possible to suture the SMAS under tension, the tension is not maintained because the SMAS elongates as it undergoes the biomechanical process of stress relaxation.[9]

In some situations, the application of a traction force to an incompletely released SMAS flap may cause a distortion. If there is a resistance to movement that is greater in one direction than another, the magnitude of displace-

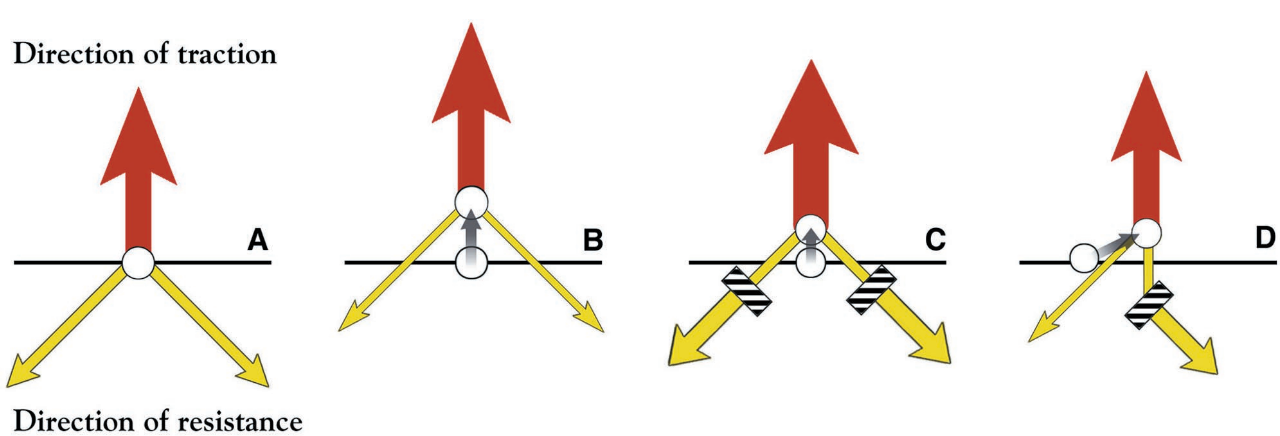

FIG. 1. (*Left*) Force diagram showing that an equilibrium exists when the force of traction applied to the force point (*white circle*) is not greater than the force of resistance provided by the tissues. (*Second from left*) Reduction of tissue resistance by release of the immediate retaining ligaments allows displacement of the force point in the direction of the traction force. Displacement continues until a new equilibrium is reached between the traction force and the increasing tissue resistance. (*Second from right*) Traction force applied in the presence of resistance (*cross-hatched*) at a distance from the force point. Application of an increased traction force may achieve some displacement of the force point. Although not sufficient to overcome the resistance, the force may be sufficient to stretch the SMAS between the force point and the resistance point. (*Right*) Traction force applied in the presence of a partial tissue resistance that is not symmetrical. The tension force achieves some movement but with a distortion. The displaced tissue rotates around the point of resistance as it is being drawn in the direction of traction. This results in an unintended transverse displacement of the traction point.

ment no longer relates just to the applied force and the angle of traction as an additional factor comes into play, i.e., rotation of the flap around the point of remaining fixation. The flap does not advance in the direction of the applied force and to the extent expected. Rather, there is an angular displacement such that there may be excessive movement of the flap in the "wrong" direction relative to the limited movement in the intended direction (Fig. 1, *right*). A classic example of this distortion is the lateral sweep of the cheek.[10] This undesirable sequela of face lifts can result from SMAS flap surgery when the anterior masseteric-cutaneous ligaments remain intact and block the intended vertical displacement of the midcheek. Instead, the more mobile lower part of the flap along the jaw line rotates around the lowest of these ligaments and is displaced posteriorly (Fig. 2).

A similar situation is prone to occur around the lateral canthus when vertical traction is applied to the suborbicularis oculi fascia in this area. If the resistance inferolateral to the force point has been released but the medial restriction persists (due to the orbicularis retaining ligament remaining intact), an oblique fold of the flap may result. The outer part of the lower lid remains uncorrected until the restriction to mobility imposed by the resistance of that ligament has been released. These examples illustrate a key principle of SMAS flap surgery that where there is a block between the force point and the area requiring correction, it is not possible for SMAS flap surgery to improve that area.

When SMAS flap surgery was introduced, it was not appreciated that there is a key functional differentiation of the cheek into two parts. The outer or lateral cheek (preauricular) is separated from the medial cheek by an internal vertical ligamentous boundary. This boundary is located along the line formed by the angulation of the underlying facial skeleton at the superior temporal line, the lateral orbital rim, and at the lateral border of the body of the zygoma. The key ligamentous attachments of the superficial fascia to the underlying skeleton occur along this line. The important muscles of facial expression are located medial to this line, and it is here where most of the facial aging occurs.[5,11,12]

As surgery of the SMAS was originally described, the release was restricted to the outer part of the face. Specifically, it did not release

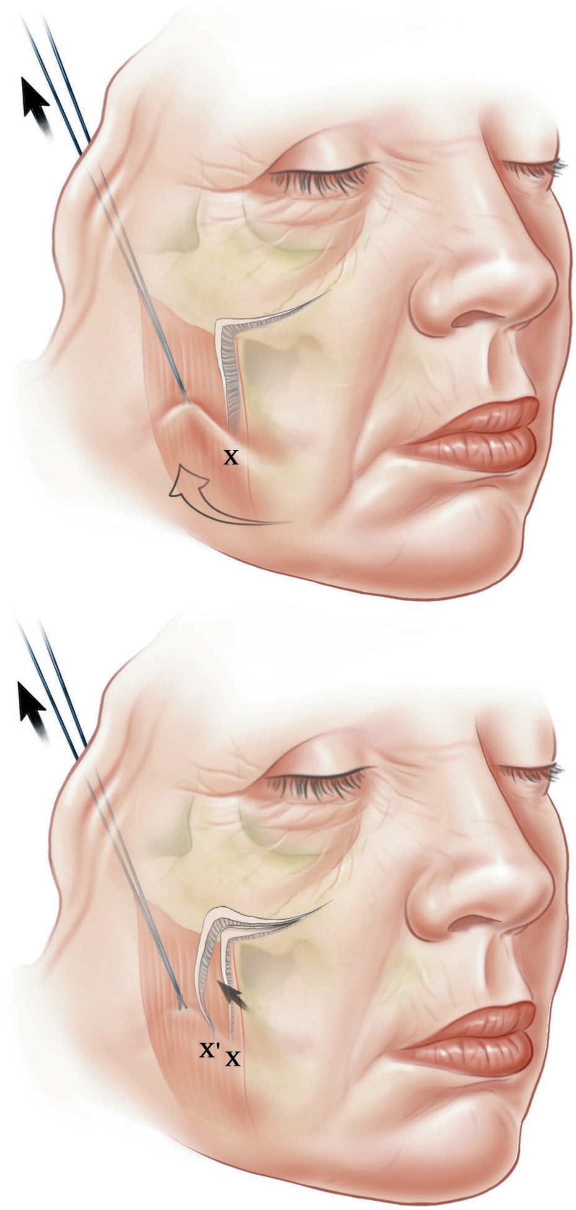

FIG. 2. (*Above*) The lateral sweep deformity of the cheek that can occur in SMAS flap surgery, despite vertical traction. This outcome occurs from the failure to properly release the anterior masseteric-cutaneous ligaments. These ligaments are inherently stronger above, nearer the zygoma, and weaker below. Rotation of the more mobile lower part of the flap results in an excessive posterior displacement, which contrasts with the insufficient vertical lift. *Point X*, the pivot point, is the lowest intact ligamentous resistance. (*Below*) Complete release of the midcheek retaining ligaments allows an even redraping of the superficial fascia of the cheek in the direction of the traction force.

the vertical ligamentous boundary to allow an effect on the medial part of the cheek. The extended SMAS technique, which was a key evolution of SMAS surgery, continues the release beyond this ligamentous line, i.e., it takes up the release at the level at which it was discontinued when performing the traditional SMAS release.[13]

VECTORS: BASIC PRINCIPLES

According to Oxford, *vector* is defined as a quantity having direction as well as magnitude, denoted by a line drawn from its original to its final position.

- In the face-lift context, a vector diagram may be used to illustrate the force applied to the flap, or alternatively to illustrate the resultant effect, namely the displacement of the flap.
- When a force is applied in a particular direction (e.g., vertical) the result is maximal in that direction, but there is also an effect at an angle to the primary force (Fig. 3, *left*).
- If the force is applied at an angle to the vertical, the resultant effect has both a vertical and horizontal component (Fig. 3). This effect can be demonstrated by use of the X-Y coordinates of classic two-dimensional geometry. These show how the relative distribution of effect between the vertical and horizontal varies according to the angle at which the force is applied. With a 45-degree angle of traction, there is as much vertical lift as posterior displacement (Fig. 3, *right*). Although vertical lifting is paramount for a successful face lift, it is important to realize that a component of vertical lift also occurs with face-lift flaps, which have other than directly vertical traction. As a corollary, a major vertical lift can be achieved while at the same time providing a significant component of posterior displacement. When oblique traction is applied to the lateral face (i.e., lateral to the body of the zygoma), this reduces the distortions that are prone to result from a purely vertical lift, such as crowding of the lateral canthus crow's foot, area, and excessive upward displacement of the sideburn.

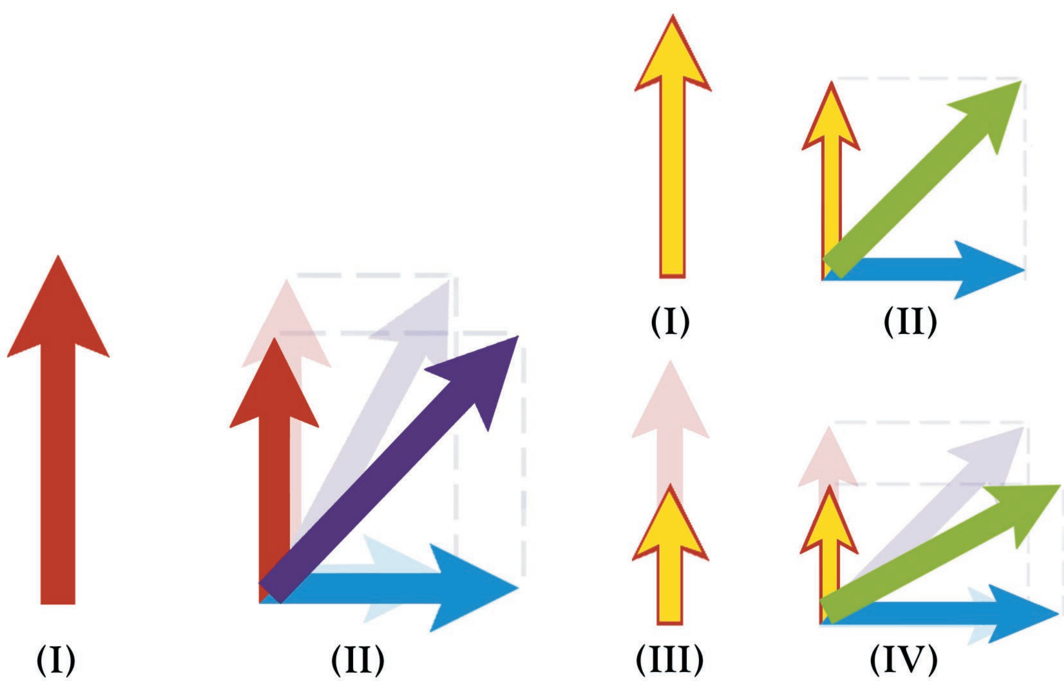

FIG. 3. Classic two-dimensional geometry X-Y coordinates (length of *arrow* denotes magnitude of force). (*Left*) Force vectors: *I*, vertical traction; *II*, force applied at an angle has a vertical component and a horizontal component. The proportional distribution between vertical and horizontal varies according to the angle of the primary vector. A vertical lift occurs without a directly vertical force. (*Right*) Movement vectors (length of *arrow* denotes magnitude of displacement): *I*, vertical displacement. *II*, Movement at an angle (*green arrow*) follows the direction of force if there is no restriction. There are accompanying vectors of vertical and horizontal displacement. *III*, Restriction of the vertical displacement due to a partial, symmetrical resistance. *Shaded arrow* indicates the reduction from expected displacement. *IV*, Resistance to displacement, which is unequal. The magnitude of displacement no longer relates just to the magnitude and angle of the applied force. The unpredictable variable of the unseen and unequal resistance causes a reduction of the expected displacement in one direction (vertical) more than the other (horizontal).

FIXATION

The dermis of the face is attached to the facial skeleton by a multilink fibrous support system that comprises the retaining ligaments and the superficial fascia, which includes the SMAS and the retinacula cutis.[11] A taut and intact retinacula cutis faithfully transmits the shape and movement of the superficial fascia to the skin. The function of the face imposes unique and conflicting requirements on its superficial fascia, namely the need for both fixation and movement. The functions of facial expression demand precisely controlled movement such as occurs with lip control in articulation. To restrict the amount of movement to the degree intended and to the area of the face intended, stability of the tissues is required, which takes the form of the deeper fixation of the superficial fascia. An example of the localization of movement is the prevention of traction on the lower lid when the muscles around the mouth contract. Strong fixation is also required to resist the external forces of gravity and of traction, such as occurs in sleeping with the cheek buried in a pillow.

The anatomic pattern of ligamentous fixation of the superficial fascia to the facial skeleton defines boundaries that compartmentalize the face into several regions (Fig. 4). Three of these are component parts of what is externally visualized as the cheek, i.e., the lateral cheek and the prezygomatic and infrazygomatic parts of the medial cheek, in addition to the other regions, the lower lid, lower temple,

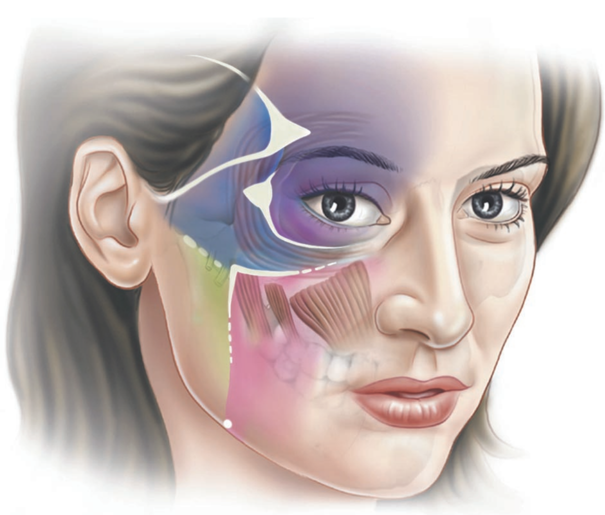

FIG. 4. Regions of the face. Compartmentalization occurs from the pattern of ligamentous fixation of the superficial fascia to the periosteum and deep fascia. The boundary of each region is formed by a ligament.

upper lid, and forehead. The stabilizing effect that occurs at these ligamentous boundaries quarantines the movement resulting from muscle contraction within each region so that, at least in youth, movement does not transmit into the superficial fascia of adjacent areas. The ligamentous fixation has a shock absorber-like effect, which modulates the degree of tissue displacement upon muscle contraction.

The laxity that develops in the multilink fibrous support system of the face is due to a progressive weakening of the supporting connective tissue. This presumably arises from the combination of intrinsic, age-related atrophy and degeneration of the connective tissue compounded by the "wear and tear" effect from the repeated displacement of the soft tissues consequent on the action of the facial muscles. Once some initial laxity develops, an exponential effect would occur as the laxity places more strain on the remaining and slowly diminishing ligamentous support. Whereas, in youth a balance exists between fixation and movement, the reduction of effective fixation means that the effect of the same muscle contraction tends to produce a greater displacement of the soft tissue with aging. The increased displacement further strains and weakens the ligamentous support.

These events would account for the acceleration of the rate of aging changes commonly seen in a woman in about her mid-forties. They also account for the apparent hyperactivity of muscle contraction, e.g., smile lines and glabella lines, at an age when muscle mass and strength are, in fact, beginning to weaken. Obviously, the influence of gravity is the same in youth as it is in age, but tissue displacement with gravity is limited in youth. Descent of tissues from the effect of gravity only occurs when the tissues have become lax. The displacement of the tissues from gravity tends to further weaken the ligamentous support. Although the vertical descent of the face so characteristic of aging[14] reflects the obvious effect of gravity, the cause of the underlying laxity reflects the increasing mobility of the tissues as a result of the muscular activity rather than the laxity having arisen primarily from the long-standing influence of gravity (Fig. 5). Notwithstanding, that laxity can occur in the absence of muscle activity (and muscle tone) as seen in long-standing facial nerve palsy.

The direction of the weakening and of displacement of the connective tissues from repet-

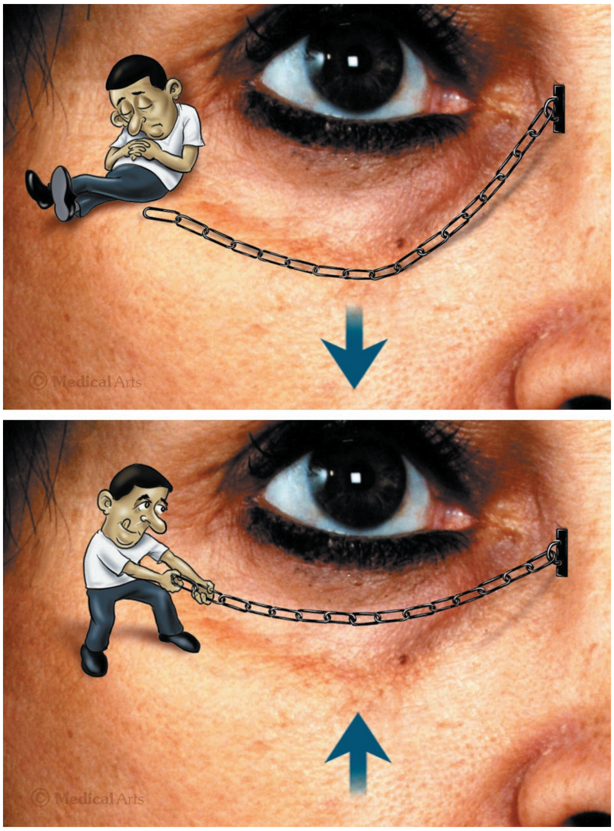

FIG. 5. The displacement of soft tissue that occurs under the influence of gravity is conditional on laxity being present. The correction of laxity in the vector of displacement (seen here as taking the slack out of the *chain*) nullifies the apparent effect of gravity.

itive muscle shortening and stretching differs according to the configuration of each muscle (Fig. 6). For linear muscles, e.g., zygomaticus major and corrugator supercilii, the laxity tends to be parallel to the direction of shortening of the muscle fibers. Whereas, for those muscles in which the fibers follow a curve, e.g., orbicularis oculi pars orbitalis and medial platysma, contraction of the muscle fibers causes a radial, or centripetal displacement force on the supporting connective tissue. Over time, medial platysma contraction eventually pulls the supporting tissue away from the depth of the neck concavity. It is not the muscle contraction that changes over time but the laxity of the fascial support that allows the platysma banding. Similarly, the part of orbicularis oculi that courses over the temple eventually becomes displaced toward the lateral canthus as a result of a weakening of its fibrous support, as does the part of orbicularis oculi that directly overlies the body of the zygoma. The action of orbicularis oris, the most powerful muscle of facial expression, is the major factor contributing to laxity of the medial cheek, which is the most mobile and least supported part of the face. The tissue displacement is directed medially, but when laxity develops, it is held up at the nasolabial furrow.

There are multiple vectors of displacement in the aging face. This is because each of the muscles of facial expression has its own direction of connective tissue laxity. The correction of each vector of displacement requires its own vector of fixation. Fortunately, use of the SMAS provides increased opportunities for controlling the directions of lift. This situation is quite different from that in subcutaneous and subperiosteal flap surgery in which a single, mostly vertical, vector is used. Once the retaining ligaments have been fully released, several anatomic regions have been entered into and have become as one. With the original, limited release SMAS surgery, it was considered to be an advantage to have two vectors; one direction for the SMAS, and a different vector for the skin flap.[15] When a properly released SMAS flap is used, multiple vectors are possible.[16,17] The use of multiple vectors enables the appropriate vectors of correction for each region of the face.

If strong, nonabsorbable sutures are used for the surgical fixation, what is effectively being performed is a replication of the original type of ligamentous fixation akin to that in joint surgery.[17] These sutures can hold a substantial, ligament-like, strength into the superficial fascia if they are placed where the fascia is reinforced. This reinforced area occurs where the retaining ligaments pass through the SMAS into the retinacula cutis. Rather than suturing the mobilized SMAS to a mobile area, as occurs in suturing to the nonmobilized SMAS, the SMAS flap can be fixed rigidly if it is sutured back to the appropriate part of the underlying periosteum or deep fascia. In restoring the anatomy of ligamentous fixation, the sutures appose the SMAS directly to the periosteum, which is in contradistinction to the use of looped suspension sutures. The closer the force point for application of tension to the fixation point on the skeleton, the less potential for subsequent loss of position as a result of relaxation of the intervening bridge of SMAS. The use of multiple sutures spreads the load and reduces the force per unit area at each fixation point.

The sutures into the SMAS flap need not be restricted to the cut edge of the flap. With the intact flap raised, the sutures can be placed through the underside of the appropriate parts of the flap. This method is not unlike the external SMAS technique where multiple sutures are placed into the outer surface of the intact SMAS layer at selected locations. The direction of placement of each suture provides a directional effect to the connective tissue support.

The horizontal line of the zygomatic ligaments is located in relation to the origins of the zygomatic and levator muscles of the upper lip (Fig. 4). As the series of suture/ligaments are replaced along the lower part of the body of the zygoma, the ligamentous boundary separating the prezygomatic and infrazygomatic regions is reconstituted. The orientation of each suture into the zygoma is parallel to the direction of the fibers of each individual muscle which, of course, varies (Fig. 7). Adjacent to levator labii superioris, the vector of correction is directly vertical, whereas laterally, the orientation of the sutures is more oblique commensurate with the orientation of zygomaticus major. Accordingly, in the correction of the medial infrazygomatic cheek and nasolabial fold, there is not one but several vectors (Fig. 7). Overlying the zygoma, the vectors for orbicularis oculi are more complex. Lateral to the lateral canthus, the sutures are oriented partly parallel to the muscle fibers but with an outward vector. In the temple, the direction of the sutures follows the direction of the superior temporal line to reverse the centripetal displacement of the muscle with its related connective tissue support. The sutures into the superficial fascia are placed in the connective tissue of the SMAS between the muscles or into the suborbicularis oculi fascia.

The periosteum of the zygoma varies in its ability to hold sutures. Where the periosteum is not strongly attached to the bone, sutures are prone to cut through the weak periosteum or else to detach the periosteum from the bone.

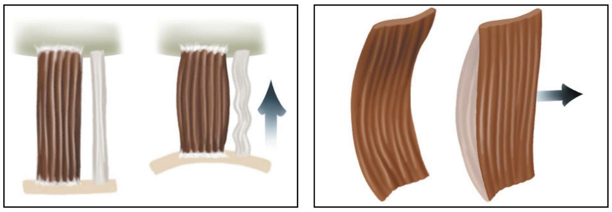

FIG. 6. Linear muscles undergo linear displacement on contraction, whereas radial muscles undergo centripetal displacement.

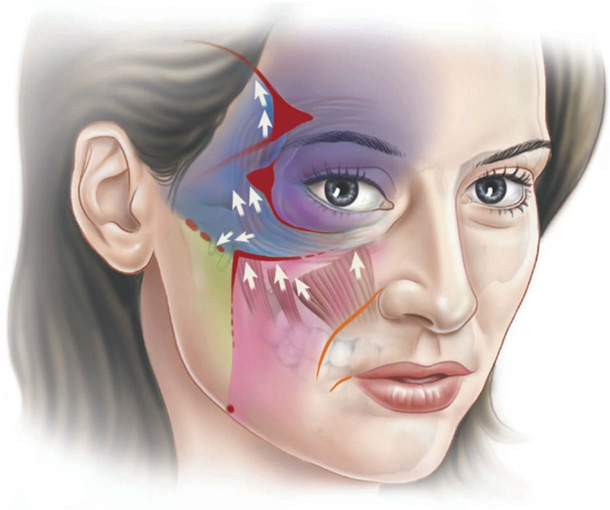

FIG. 7. Vectors of fixation. Each *arrow* indicates a point of suture fixation of the superficial fascia to the periosteum. The vector of each is opposite to the vector of displacement arising from laxity.

The Sharpey's fibers from ligament and muscle origins reinforce the periosteum as they course through this layer to embed into the cortical bone. The much stronger periosteal attachment to the lower part of the zygoma enables strong fixation exactly where it is required, in the vicinity of the zygomatic ligaments adjacent to the origins of the strong muscles to the lip. The other area of strengthened periosteum is along the orbital rim where the arcus marginalis is formed as a reinforcement of the periosteum where it is fused with the periorbita and septum orbitale.

The concept of positioning the fixation at the location of the original ligamentous fixation is quite different from that in the original SMAS surgery, when the SMAS release was discontinued before the midcheek ligaments were exposed. The SMAS fixation in that situation could only be peripheral and was under tension. Nowadays, with the recognition that release of these ligamentous attachments is the key to correction of the medial cheek, the fixation can also be at this level.

By reattaching the support of each anatomic region separately to the facial skeleton at the location of the original ligamentous fixation, tension across the entire SMAS flap is avoided. An incremental recontouring of the shape of the face results. Tension is an anathema to a correct result, because it produces a flatness with loss of contour.[18] Such a flap would tent across the depth of the infrazygomatic concavity and thin and flatten over the prominence of the zygoma.

Using multiple-level and central rather than peripheral fixation allows the three-dimensional shape of the face to be restored. This method results in an increased surface area of the face in contrast to the flattening and shortening effect associated with straight out tightening procedures. There is a reduction in the amount of redundant facial skin to be excised because of this recontouring as well as from the reduction of skin closing tension in front of the ear.

Summary

- The principles underlying SMAS face-lift surgery are different from those of traditional face lifts.
- SMAS flap surgery works at the level at which mobility and aging laxity are occurring.
- SMAS flaps tighten connective tissue laxity to reposition and restore tone to the superficial fascia. This approach reduces apparent muscular hyperactivity.
- Complete SMAS release is necessary to avoid tension and distortion.
- SMAS flap fixation should replicate the original fixation of the superficial fascia.
- Nonabsorbable sutures mimic ligaments.
- The fixation respects the natural boundaries between facial regions.
- Fixation at the several original locations avoids the need for a mass tightening and flattening of the SMAS.

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