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BIOFORM MEDICAL
INTRODUCTION
The brow and periorbital region play a central role in the expression of emotion, health, and aging. Successful brow lifting is predicated on a fundamental knowledge of the anatomy, a thorough understanding of the aging process, an artistic grasp of brow aesthetics, and a logical well-executed surgical plan. The aesthetic goals of browplasty include the correction of eyebrow ptosis, muscle imbalance or activity, forehead rhytids, brow shape and lid aesthetics, lateral brow laxity, and abnormal or unattractive facial expressions.1,2

HISTORY
In 1919, Passot3 was the first to report brow lifting in the literature. He used multiple elliptical skin excisions to elevate the brow and to diminish crow’s feet. Subsequently, Hunt4 described a variety of techniques to address the brow, including the coronal incision in the hair-bearing scalp, a hairline incision, and direct forehead incision. During the ensuing 20 to 30 years, the forehead lift lost favor because of its transient longevity. During that time, attempts to improve the durability of the operation included transection of the temporal branch of the facial nerve or injection of alcohol into the motor nerves.5,6 Those efforts were unsuccessful and fraught with complications.1,7

During the 1960s, interest in brow lifting was renewed. Failures of earlier brow lifts were attributed to the persistent activity of the forehead muscles. The McIndoe-Beare techniques8 for modifying the frontalis and corrugators were updated by Marino and Gandolfo.9 Vinas10 also made some very astute observations that remain relevant even today:

1. An inelastic aponeurotic-muscle layer, formed by the frontalis and its extensions, occupies the frontal region and expands laterally toward both temporal regions. This layer adheres to the skin and does not permit free movement of it. Traction on the frontotemporal region with a finger will show this fixation of the skin, as it does not cause the wrinkles to disappear in contrast to the results of a similar test in the lower faciocervical area, where the skin glides easily over the subjacent tissue.
2. There are adhesions that prevent free movement of the soft tissues of the supraorbital regions over the bony orbital rims. In our experience, unless these adhesions are eliminated, traction from above will not give a permanent lift to the eyebrows.”

Subsequently, surgeons investigated different approaches and planes of dissection. However, the brow received little attention relative to other aspects of facial rejuvenation. The advent of endoscopic brow rejuvenation in the early 1990s11,12 stimulated increasing attention to browplasty. A recent review13 discussed 262 articles that were published between 1966 and 2008 on
the topic of brow lift. One hundred forty-two (54%) of the articles were published during the last 10 years.

ANATOMY
In this section, we present summaries of the anatomy related to brow lifting. For more in-depth study, we refer the reader to descriptive textbooks and atlases by Baker et al., Barton, Knize, Mathes, Nahai, and Zide and Jelks.

Muscles
The frontalis muscles are paired extensions of the galea aponeurotica and insert into the supraorbital dermis by interdigitating with the orbicularis oculi muscle. The superficial and deep galea layers continue to the upper palpebral margin as the anterior and posterior sheaths of the frontalis and orbicularis muscles. A fat pad develops within a split in the posterior muscle sheath at the brow. The galea is continuous with the superficial temporal fascia laterally, which is continuous with the superficial musculoaponeurotic system (SMAS) inferiorly. The fixation of the brow has been examined by Knize, who emphasized the importance of the fusion plane between the galea, temporalis, and periosteum at the temporal crest.

The depressors of the brow are the procerus, corrugator supercili, depressor supercili, and orbicularis oculi muscles. All except the sphincter pass within the fat pad deep to the frontalis. The procerus muscles originate from the upper lateral cartilages and nasal bones and insert into glabellar skin at the medial edges of the frontalis. Contraction produces transverse wrinkling at the radix of the nose.

The corrugator muscle has both a transverse and an oblique head. The procerus, depressor supercili, and oblique head of the corrugator muscle originate from the superior-medial orbital rim and share a parallel course before inserting into the dermis under the medial eyebrow. The transverse head of the corrugator supercili muscle originates from the medial superior orbital rim and inserts into the dermis just superior to the middle third of the eyebrow. The transverse head of the muscle moves the entire eyebrow medially, producing both vertical and oblique glabellar skin creases. The procerus, depressor supercili muscle, and oblique head of the corrugator supercili muscle produce oblique glabellar skin lines.

In a recent study of cadaveric dissections, Janis et al. described the topography of the corrugator muscle in great detail and noted that the corrugator supercili are much larger than previously described (Fig. 1). At its medial origin, the corrugator begins 2.9 mm from the nasion and extends laterally to a point 43 mm from the nasion or 7.6 mm medial to the lateral orbital rim. The most cephalic extent (apex) of the muscle is 32.6 mm superior to the nasion-lateral orbital rim plane. At its medial origin, the most caudal muscle fibers are approximately 1 cm cephalad to the nasion-lateral orbital rim plane.

**Figure 1.** Comprehensive corrugator supercili muscle dimensions. Artistic rendition (proportionate scale) of all measured data points of corrugator supercili muscle in relation to palpable bony anatomy. Note reflection of muscular interdigitation required to delineate lateral extent of corrugator supercili muscle. (Reprinted with permission from Janis et al.)

The orbicularis oculi muscle is the sphincter of the eyelid. This broad, thin, oval muscle is adherent to the overlying skin and consists of three parts: a peripheral orbital portion spreading over the forehead and cheek; a palpebral portion that constitutes the voluntary muscle of the eyelids; and a small lacrimal portion associated with the medial palpebral ligament. The orbital portion attaches to the medial canthal tendon, the nasal part of the frontal bone, along the inferomedial orbital margin, and interdigitates with the corrugators medially. Laterally, the orbital portion of the orbicularis continues around the orbit without interruption at the lateral canthus into the zygomatic area. Contraction of the orbicularis results in downward displacement of the lateral brow.
Contraction of the medial head of the orbital portion depresses the level of the medial eyebrow but does not uniformly contribute to the formation of oblique glabellar skin lines. The palpebral portion of orbicularis oculi spreads concentrically in the subcutaneous tissue of the upper and lower eyelids. The palpebral orbicularis oculi has pretarsal and preseptal segments.

**Ligaments and Attachments**

The orbicularis oculi is anchored by well-defined ligamentous attachments. Muzaffar et al. provided a detailed description of the attachments. Medially, the orbicularis has a direct attachment to the inferior orbital rim from the region of the anterior lacrimal crest to approximately the level of the medial limbus. Laterally, the attachment is indirect and provided by the orbital retaining ligament (ORL) (Fig. 2). The anatomy of the ORL and its relationship to the orbital septum were clarified in cadaver studies by Ghavami et al. The authors found the ORL to be circumferential in nature and consistent in every specimen. Although the ORL and orbital septum merge at the orbital rim into a thickening called the *arcus marginalis*, the two are always noted to be distinct structures (Fig. 3).

The ORL extends from the periosteum just outside the orbital rim to the fascia on the undersurface of the orbicularis oculi. At its lateral extent (and in the region of the lateral canthus), the ORL merges with the “lateral orbital thickening” (LOT). The ORL is more lax and greater in length laterally compared with medially, where it is more taut and shorter (Fig. 4). The LOT represents a triangular condensation of the superficial and deep orbicularis that extends across the frontal process of the zygoma onto the deep temporalis fascia. In a study conducted by Muzaffar et al., the dimensions of the LOT varied greatly with age (Fig. 5). The ORL is predictably continuous with the LOT below the lateral canthal tendon. Specifically, the ORL, LOT, and lateral palpebral raphe form a single anatomic unit in that region (Fig. 6). Release of the ORL and LOT, therefore, allows untethered redraping of all the structures.

Figure 2. Anatomy of inferior periorbital space. Medially, orbicularis oculi originates directly from orbital rim above origin of levator labii superioris. More centrally, orbicularis attaches indirectly to orbital rim by means of orbicularis retaining ligament, which courses directly on orbital side of zygomaticofacial nerve. Laterally, ligament merges into lateral orbital thickening. (Reprinted with permission from Muzaffar et al.)

Figure 3. Schematic drawing shows relationship of orbital septum and orbicularis retaining ligament (ORL). Orbicularis retaining ligament arises from orbital rim several centimeters above inferior edge. Arcus marginalis is fused area of orbital septum, orbicularis ligament, and periosteum and lies between the orbital septum and orbicularis retaining ligament. OOM, orbicularis oculi muscle. (Reprinted with permission from Ghavami et al.)
Moss et al. conducted a detailed anatomic study of the temporal and periorbital regions and provided a taxonomy for the various supporting structures. The authors divided structures into ligaments (deep fascia or periosteum to dermis), septi (fibrous wall between fascial layers), and adhesions (fibrous or fibro-fatty adhesion between deep and superficial fascia). They identified six global temporal and periorbital structures relevant to brow lifting: temporal ligamentous adhesion, supraorbital ligamentous adhesion, superior temporal septum, inferior temporal septum, lateral brow thickening, and LOT. The temporal ligamentous adhesion measures approximately 20 mm high and 15 mm wide at its base and begins 10 mm cephalad to the superior orbital rim. Moss et al. also delineated the relationships to adjacent relevant neurovascular structures: sentinel vessel, temporal branch of facial nerve, zygomaticotemporal nerve, and zygomaticofacial nerve. Their findings are illustrated in Figures 7 and 8. Sullivan et al. identified four specific retaining ligaments: three medial and one lateral. Selective release of the ligaments allows for eyebrow reshaping.

**Figure 4.** Schematic shows view from the lateral orbital rim toward nasal bones with orbicularis oculi muscle (OOM) suspended by hooks to show length and size differential between lateral and medial orbicularis retaining ligaments (ORL). Lateral orbicularis retaining ligament is longer than medial orbicularis retaining ligament in both superior and inferior orbits. Note relationships among orbicularis retaining ligament, corrugator supercilii muscle (CSM), and lateral orbital thickening (LOT). ([Reprinted with permission from Ghavami et al.](#))

**Figure 5.** Dimensions of orbicularis retaining ligament and lateral orbital thickening vary with age. Larger triangle represents lateral orbital thickening in youngest specimen. Smaller triangle within defines lateral orbital thickening in older specimens. Numbers indicate millimeters. ([Reprinted with permission from Muzaffar et al.](#))

Moss et al. conducted a detailed anatomic study of the temporal and periorbital regions and provided a taxonomy for the various supporting structures. The authors divided structures into ligaments (deep fascia or periosteum to dermis), septi (fibrous wall between fascial layers), and adhesions (fibrous or fibro-fatty adhesion between deep and superficial fascia). They identified six global temporal and periorbital structures relevant to brow lifting: temporal ligamentous adhesion, supraorbital ligamentous adhesion, superior temporal septum, inferior temporal septum, lateral brow thickening, and LOT. The temporal ligamentous adhesion measures approximately 20 mm high and 15 mm wide at its base and begins 10 mm cephalad to the superior orbital rim. Moss et al. also delineated the relationships to adjacent relevant neurovascular structures: sentinel vessel, temporal branch of facial nerve, zygomaticotemporal nerve, and zygomaticofacial nerve. Their findings are illustrated in Figures 7 and 8. Sullivan et al. identified four specific retaining ligaments: three medial and one lateral. Selective release of the ligaments allows for eyebrow reshaping.

**Sensory Nerves**

The sensory nerves of the forehead are the supraorbital and supratrochlear nerves. The supratrochlear nerve emerges from the supraorbital rim 1.4 to 1.7 cm lateral to the midline of the nasal radix, and the supraorbital nerve courses 2.4 cm lateral to the midline. Beer et al. investigated more than 1000 orbits and found wide variation between the exit patterns of the supraorbital nerve, with asymmetric findings between left and right in 74% of the specimens. Additionally, the largest distance the supraorbital nerve exited from the supraorbital rim was 19 mm. In a different study,
Webster et al. found that approximately 50% of skulls had bilateral supraorbital notches, 25% had bilateral supraorbital foramina, and 25% had one notch and one foramen. Bilateral supratrochlear notches were present in 97% of specimens.

The supraorbital nerve divides into a deep branch and a superficial branch. Janis describes four distinct branching patterns of the supraorbital nerve relative to the corrugator supercilii (Fig. 9). With pattern I (40%), the deep division sends branches that course along the undersurface of the muscle. With pattern II (34%), both the superficial and deep divisions have branches adjacent to the corrugator. Pattern III (4%) has only branching contributions from the superficial division, and with pattern IV, all branching of the supraorbital nerve occur cephalad to the bulk of the corrugator muscle. The authors found the supraorbital nerve to be more intimately related to the corrugator muscle than previously thought. However, the supraorbital nerve was not observed to perforate through the muscle in any of the cadaver specimens.

Figure 7. Lateral view shows periorbital and temporal ligamentous attachments with major neurovascular relationships. TLA, temporal ligamentous adhesion; SLA, supraorbital ligamentous adhesion; STS, superior temporal septum; ITS, inferior temporal septum; PS, periorbital septum; LBT, lateral brow thickening of periorbital septum; LOT, lateral orbital thickening of periorbital septum; SV, sentinel vessel; TFN, temporal branches of facial nerve; ZTN, zygomaticotemporal nerve; ZFN, zygomaticofacial nerve. (Reprinted with permission from Moss et al.)

Figure 8. Anterior view shows periorbital and temporal ligamentous attachments with major neurovascular relationships. TLA, temporal ligamentous adhesion; SLA, supraorbital ligamentous adhesion; STS, superior temporal septum; ITS, inferior temporal septum; PS, periorbital septum; LBT, lateral brow thickening of periorbital septum; LOT, lateral orbital thickening of periorbital septum; SV, sentinel vessel; TFN, temporal branches of facial nerve; ZTN, zygomaticotemporal nerve; ZFN, zygomaticofacial nerve. (Reprinted with permission from Moss et al.)
medial to the temporal fusion line. The deep division provides sensation to the frontoparietal scalp, and Knize suggested that arrangement is responsible for the itching and numbness patients feel after open coronal brow lift procedures. The supratrochlear nerve exits the orbit medially and enters the substance of the corrugator and then the frontalis.

**Motor Nerves**

The motor nerve of the forehead is the temporal branch of the facial nerve, which lies on the undersurface of the temporal fascia. The temporal branch of the facial nerve supplies the frontalis muscle, superior orbicularis muscle, transverse head of the corrugator supercili muscle, and superior end of the procerus muscle (Fig. 10). Pitanguy and Ramos traced the temporal branch of the facial nerve from 0.5 cm below the tragus to 1.5 cm superior to the lateral brow. The temporal branch usually runs just below the frontal branch of the temporal artery. Stuzin et al. delineated the multiple layers in the temporal region, described the course of the nerve in a three-dimensional fashion relative to the fascial planes, and suggested a safe dissection route. The concept of the

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**Figure 9.** Summary of supraorbital nerve branching pattern classification. **Left,** Type I supraorbital nerve branching pattern, most common type. **Right,** Types II through IV. **SON-S,** superficial division of the supraorbital nerve; **SON-D**<sub>CSM</sub>, branch from the deep division of the supraorbital nerve; **SON-D**<sub>D</sub>, deep division of the supraorbital nerve; **SON-S**<sub>CSM</sub>, branch from the superficial division of the supraorbital nerve. (Reprinted with permission from Janis et al.)
frontal temporal nerve triangle\(^3\) can assist in locating motor and sensory nerves in the upper face.

The zygomatic branch of the facial nerve supplies the inferior orbicularis oculi muscle, inferior end of the procerus muscle, depressor supercilii muscle, oblique head of the corrugator supercilii muscle, and medial head of the orbicularis oculi muscle.\(^2\)

Calvaria
The skull thickness varies based on location. Walden et al.\(^4\) showed that the thickness increases medially and posteriorly. Knize\(^1\) measured the thickness of the skull in various locations, with averages ranging from 5.1 mm laterally to 7.7 mm medially. The temporal bone was found to be as thin as 1.7 mm. The skull is also thin just superficial to the middle meningeal artery, measuring as little as 2.1 mm.\(^2\)

PATHOPHYSIOLOGY
Prolonged hyperactivity of the upper facial musculature produces three kinds of deformities of the forehead and brow complex: transverse forehead wrinkling (frontalis muscles), brow ptosis (corrugator and orbicularis muscles), and glabellar wrinkling (corrugator, orbicularis, and procerus muscles). Flowers et al.\(^4\) reviewed the dynamics of frontalis function as related to brow lift.

Knize\(^2\) discussed the mechanism of eyebrow ptosis in an anatomic study that identifies the balance of forces acting on the eyebrow and specific glide planes and supporting structures. He postulated that the lateral eyebrow segment becomes ptotic earlier than the medial segment because the lateral eyebrow has less support from deeper structures and the balance of forces acting on the eyebrow selectively depresses the lateral segment (Fig. 11). The author identified three forces acting on the lateral eyebrow:

1) frontalis muscle resting tone, which suspends that eyebrow segment medial to the temporal fusion line of the skull;
2) gravity, which causes the soft-tissue mass lateral to the temporal line to slide over the temporalis fascia plane and push the lateral eyebrow segment downward; and
3) corrugator supercilii muscle hyperactivity in conjunction with action of the lateral orbicularis oculi muscle, which can antagonize frontalis muscle activity and directly facilitate descent of the lateral eyebrow.”

AESTHETICS
One cannot discuss brow aesthetics without simultaneously discussing periorbital and eyelid aesthetics. Clearly defined goals of brow and orbital aesthetics are the basis of successful results in surgical rejuvenation of the upper face. The goals vary significantly with sex, age, race, culture, and personal preference. The globe by itself is entirely expressionless and depends on the surrounding soft-tissue complex to convey the myriad human emotions. Many of these aesthetic goals intertwine the forehead, brow, eyelid, and pupil into the brow and temporal region. Often, the “ideal” measurements refer back to the golden proportion, reminding us that the relative positions and distances might be more important than the absolute.\(^1\)

Farkas and Kolar,\(^5\) Flowers,\(^4\) and Wolford et al.\(^6\) reviewed the aesthetic goals of blepharoplasty. Certain
Numerical guidelines are helpful in planning the surgery. At the midpupillary line, the anterior hairline to brow distance should measure 5 to 6 cm. The distance from brow to orbital rim, brow to supratarsal crease, and brow to mid pupil should be 1 cm, 1.6 cm, and 2.5 cm, respectively.\(^2\) Canthal tilt averages 4.1 mm (+4 degrees) in women and 2.1 mm (+3 degrees) in men.\(^4\) Visible pretarsal skin should measure 3 to 6 mm\(^6\) and lash line to lid fold ranges from 8 to 10 mm.\(^4\) The upper lid should cover 2 to 3 mm of the iris, and the lower lid forms a “lazy-S” and should just meet its inferior aspect. The intercanthal distance is ideally one-fifth of the facial width at eye level and represents one eye width.\(^9\)

McKinney et al.\(^5\) analyzed 15 normal healthy volunteers with esthetically pleasing faces and observed that the average distance from the mid pupil to the upper edge of the eyebrow was 2.5 cm and the distance from the upper edge of the eyebrow to the hairline was approximately 5 cm (Fig. 12). Connell et al.\(^5\) added that the distance between the upper eyelid crease and the upper edge of the brow is approximately 15 mm in esthetically pleasing faces.

Because of naturally occurring variations in the sizes and shapes of human structures, a discussion of relationships between parts is more relevant than absolute numbers. The medial edge of the eyebrow, the medial canthus, and the lateral border of the nasal ala should all fall on the same vertical plane. The eyebrow should form a gentle arch whose peak lies at the junction of the medial two-thirds and the lateral one-third.\(^5\) The peak should ideally lie midway between the lateral aspect of the iris and the lateral canthus. Some have suggested that the peak of the brow arch should be more lateral than the classic description.\(^5\) The brow should overlie the orbital rim in men and be several millimeters above the rim in women. The edge of the lateral eyebrow should lie slightly above the medial brow. A line drawn between the lateral eyebrow and the nasal ala should intersect the lateral canthus.\(^5\) Ellenbogen\(^1\) illustrated the aesthetic relationships of the brow to other facial features (Fig. 13), as originally described by Westmore\(^5\):

- In women, the eyebrow begins medially at a vertical line drawn perpendicularly through the ala of the nose.
- In women, the brow should arch to above the supraorbital rim; in men, it should arch along

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**Figure 11.** Forces contributing to lateral eyebrow ptosis. Unsupported eyebrow lateral to the temporal fusion line of the skull (TL) is pushed down by the gravity-driven descent of the temporal fossa soft tissues. Lateral-most limit of the frontalis muscle resting tone suspension of the eyebrow extends just over the zone of fixation (slanted lines) along the temporal fusion line of the skull. Hyperactive corrugator supercilii muscle and lateral orbicularis oculi muscle action can antagonize frontalis muscle action and actively facilitate the descent of the superficial temporal fossa soft tissues. (Reprinted with permission from Knize.\(^5\))

**Figure 12.** Distance from midpupil to top of brow should be at least 2.5 cm. If shorter, brow ptosis exists. Forehead height averages 5 cm in women and 6 cm in men. (Modified from McKinney et al.\(^5\))
the rim.
- The lateral brow terminates at an oblique line drawn through the ala of the nose and the lateral canthus.
- The medial and lateral ends lie at approximately the same horizontal level (the medial end has a club head configuration that gradually tapers laterally).
- The apex of the brow lies on a vertical line directly above the lateral limbus.

Gunter and Antrobus\(^55\) provided further criteria that contribute to an aesthetic brow:

- The medial brow should be a continuation of the aesthetic dorsal line of the nose.
- The medial brow should start approximately above the medial canthus.
- The vertical distance from the supraorbital arch to the peak of the brow will differ. However, the peak should rarely be more than 10 mm above the most caudal portion of the medial brow. It should be higher in women than in men.
- The medial brow should be lower than the lateral peak.
- The eyelids should remain aesthetic with the brow elevated, otherwise surgical alteration of the eyelids might be indicated.
- The periorbital area should have its own balance. It should resemble an oval consisting of the eyebrow superiorly, the nasal dorsal line medially, the nasojugal groove inferiorly. The eye should be in the center of the oval, and the oval should balance with the rest of the face (Fig. 14).
- Aesthetics of the male brow differ. The male brow tends to be less arched and usually flat or nearly horizontal. The lateral brow is usually more prominent in men.

Figure 13. Spatial relationships of ideal eyebrow. B, medial brow; E, brow apex; C, lateral brow. (Reprinted with permission from Ellenbogen.\(^{54}\))

Figure 14. Periorbital oval. (Reprinted with permission from Gunter and Antrobus.\(^55\))

Final brow position and shape should be determined during preoperative discussions with the patient in the context of facial aesthetics, individual preferences, and facial shape. A recent study by Baker et al.\(^56\) showed that brow aesthetics should take facial shape into consideration. Using computer imaging software, the authors morphed a model’s face into different shapes (round, square, oval, and long) and applied the classic description presented by Westmore\(^52\) versus the recommendations of a professional makeup artist. No significant difference was noted between the classic and modified eyebrow for oval or round facial shapes. However, the brow modified by the professional makeup artist was found to be more attractive with square and long facial shapes. Specifically, square faces favored a softer curve with the arch lateral to the lateral limbus and long faces were more attractive with a straighter brow, avoiding a high arch that may add length to the face.
SURGICAL GOALS
Matarasso and Hutchinson\textsuperscript{57} divided the goals of forehead-brow rhytidoplasty into primary and secondary indications. The primary indication for surgery is ptosis of the forehead and eyebrows. The secondary criteria include frown muscle imbalance, transverse forehead rhytids, upper eyelid aesthetics, lateral brow-temporal laxity, and abnormal and/or unattractive expression. A retrospective review, however, showed a relatively uniform distribution of patients into each category (primary or secondary).\textsuperscript{2} The primary and secondary indications and their corresponding surgical goals are shown in Table 1.\textsuperscript{2} An algorithm for selecting the appropriate forehead brow procedure based on the patient’s main concern is shown in Table 2.\textsuperscript{57}

The overall goals of surgery are the restoration of brow position, shape, and symmetry. For a soft, esthetically pleasing result, it is important to avoid overcorrection of brow position and excessive elevation of the medial brow. Over-elevation of the brow and abnormal shape are associated with perceived tiredness, sadness, anger, or surprise.\textsuperscript{55,58} In addition, any secondary criteria also need to be addressed. The selection of incisions, dissection, and adjunctive procedures needs to be tailored to specific patient desires.

TECHNIQUE
With the aesthetic goals clearly in mind, the approach, plane of dissection, and means of fixation are chosen.

Incisions
Direct
Flowers et al.\textsuperscript{41} suggested that the brow is subject to the elastic band principle: the farther away the suspension point is from a weight attached to an elastic band, the less effective the lift will be. The direct or superciliary excision of an ellipse of skin and subcutaneous fat was first described by Passot in 1919.\textsuperscript{7} In 1964, Castanares\textsuperscript{59} presented his results, which attested to predictable, controlled elevation of the brow. Vinas et al.\textsuperscript{10} described two techniques for brow lift, one of which was a butterfly-wing pattern of excision, emphasizing resection from the lateral brow.

The direct excision approach is most often taken in men because of the opportunity to hide the scar above the thicker male eyebrow and because other approaches cannot be hidden if the patient is balding. The most appropriate candidates for the direct brow

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### Table 1

<table>
<thead>
<tr>
<th>Candidates</th>
<th>Indications</th>
<th>Goals</th>
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<tbody>
<tr>
<td>Primary</td>
<td>Eyebrow malposition (ptosis)</td>
<td>Elevate forehead and eyebrows</td>
</tr>
<tr>
<td></td>
<td>Senile</td>
<td>Balance, position, symmetry</td>
</tr>
<tr>
<td></td>
<td>Congenital</td>
<td>Minimize corrugator-procerus activity and central frown folds</td>
</tr>
<tr>
<td>Secondary</td>
<td>Frown muscle imbalance</td>
<td>Decrease frontalis muscle hyperactivity and transverse rhytids</td>
</tr>
<tr>
<td></td>
<td>Forehead rhytids</td>
<td>Confine the eyelid incision within the tarsal crease</td>
</tr>
<tr>
<td></td>
<td>Enhancing medial and/or lateral eyelid incision (aesthetics)</td>
<td>Restore temporal, lateral brow, and canthal regions</td>
</tr>
<tr>
<td></td>
<td>Lateral brow laxity (temporal lift)</td>
<td>Adjust brow position to normalize expression</td>
</tr>
<tr>
<td></td>
<td>Abnormal and/or unattractive expression (e.g., sad, tired, angry)</td>
<td>Adjust brow position to normalize expression</td>
</tr>
</tbody>
</table>
lift are male patients older than 50 years with eyebrow ptosis and lateral hooding, well developed crow’s feet, long dense eyebrows, and low transverse forehead wrinkles. The biggest disadvantage of a direct technique is the potential for a perceptible scar at a visible portion of the face. Some authors have found that the scar is hardly noticeable after 6 to 9 months.

**Midbrow**

Excision of a strip of midforehead skin is advocated for patients who have deep forehead rhytids, to conceal the scar, and in those who have male pattern baldness, in whom a coronal lift is impossible. This approach, originally described by Gurdin and Carlin in 1972, has the additional advantage of advancing the hairline forward. Advocates of the midbrow lift tout its advantages: 1) moderate undermining above the frontalis muscle, 2) no hairline distortion, 3) precise sculpting of the entire brow, and 4) access to the superior orbital rim. Its primary disadvantage is the position of the scar.

**Transblepharoplasty**

Sokol and Sokol described a transblepharoplasty brow suspension that involved tacking a soft-tissue eyebrow flap to a superiorly based orbital rim periosteal flap. McCord and Doxanas reported a method of resecting the brow fat pad and suspending the brow from the periosteum above the brow to the preseptal orbicularis.

Others have performed more extensive forehead dissections through the blepharoplasty incision. Leopizzi reported performing wide supraperiosteal dissection of the lateral orbicularis through an upper blepharoplasty incision, transecting the “zone of fixation” where the superior temporal line joins the superior orbital rim. The lateral orbicularis oculi muscle is raised with one non-absorbable suspension stitch in the deep temporal fascia. Paul described a transblepharoplasty subperiosteal brow lift with

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**Table 2**

**Algorithm for Selecting Appropriate Forehead-Brow Procedure Based on Patient’s Main Concern and Any Proposed Concomitant Surgery**

<table>
<thead>
<tr>
<th>Indications</th>
<th>Associated Procedures</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forehead rhytids</td>
<td>None</td>
<td>Botulinum toxin ± laser resurfacing*</td>
</tr>
<tr>
<td>Glabellar creases (corrugator muscle hypertrophy)</td>
<td>None</td>
<td>Endoscopic corrugator muscle excision or botulinum toxin ± laser resurfacing*</td>
</tr>
<tr>
<td></td>
<td>Upper eyelid surgery</td>
<td>Corrugator muscle excision through upper lid ± laser resurfacing</td>
</tr>
<tr>
<td>Lateral brow laxity</td>
<td>None</td>
<td>Limited procedure (i.e., endoscopic, temporal lifts), upper lid browpexy</td>
</tr>
<tr>
<td></td>
<td>Rhytidectomy</td>
<td>Lateral brow lift through temporal aspect of facelift incision</td>
</tr>
<tr>
<td>Brow ptosis</td>
<td>With or without rhytidectomy</td>
<td>Coronal brow lift, endoscopic brow lift, anterior hairline brow lift for high (&gt;5–6 cm) forehead</td>
</tr>
</tbody>
</table>

*In patients desiring botulinum toxin treatment in conjunction with browpexy, the botulinum toxin should not be injected laterally (leaving a strip of frontalis muscle intact) if the depressor orbicularis oculi are treated. An array of soft-tissue fillers and substitutes (e.g., collagen replacement procedures, fat injections, liquid injectable silicone) can also be used.
corrugator and procerus resection. Stuzin \(^6\) also reported performing a large portion of the brow dissection through a blepharoplasty incision, although he used an endoscope to complete the dissection through the zone of fixation. Langsdon et al. \(^48\) reported widely undermining in the subgaleal plane through an upper eyelid incision medial to the temporal line. Suspension sutures and absorbable anchors are used to support the brow. Cintra and Basile \(^69\) described a combined approach that included transblepharoplasty and temporal incisions.

Knize \(^70\) and Guyuron et al. \(^71\) described a transblepharoplasty approach to the corrugator supercilii and procerus muscles for the treatment of glabellar wrinkles. Brow contouring and shaping can also be accomplished through an upper blepharoplasty incision. Resection of the retro-orbicularis fat can soften and flatten the heaviness and bulkiness in the upper periorbital and brow region. \(^72,73\) The fat pad overlies the lateral orbital rim and extends outward toward the end of the brow. Zarem et al. \(^74\) described performing browpexy through an upper lid incision to prevent the brow from dropping below the superior orbital rim.

**Coronal**

In 1962, Gonzalez-Ulloa \(^75\) combined a coronal incision for forehead lifting with traditional rhytidectomy for the lower face. Interest in the technique remained sporadic until Vinas et al. \(^10\) reported 250 cases of frontotemporal “rhytidoplasty.” Connell and Marten \(^76\) indicated that every 1 mm of eyebrow elevation produces 1.5 mm of retro-displacement of the anterior hairline. The incision, therefore, should be performed in patients who have low hairlines or in whom the predicted shift is esthetically acceptable. Flowers and Ceydeli \(^77\) reported adhering to a “five-to-one” rule with which each 5 mm of scalp excision results in 1 mm of long-term brow elevation. In bald or balding men, Connell and Marten used a vertex incision further posterior, where it is not visible in conventional photographs. Other patterns are shown in Figure 15. Flowers and Ceydeli recommended having at least 4 cm of hair remaining after scalp resection; Barton \(^15\) recommended 5 cm.

Excellent descriptions of the classic coronal brow lift can be found in articles by Ellenbogen \(^54\), Flowers and Ceydeli \(^77\), Kaye \(^1\), Ortiz-Monasterio et al. \(^78\) and Pitanguy \(^79\). Aldo Mottura \(^80\) presented an alternative of galeal plication after limited incision dissection in the subgaleal plane. With that method, skin is excised and the galea is plicated through a coronal incision. The coronal open brow lift usually provides the most effective lift and is best suited for heavy tissues or prominent eyebrow ptosis. \(^81,82\)

**Hairline**

Hunt \(^4\), in 1926, placed an incision along the anterior

![Figure 15. Types of incision used in brow lift. A, hairline; B, gull wing; C, vertex; D, lambdoidal; E, W incision; F, lambdoidal paddle; G, interlocking Ms. (Reprinted with permission from Connell and Marten.\(^76\))](image-url)
hairline in an attempt to reduce forehead wrinkling. McKinney et al.\textsuperscript{50} recommended the anterior hairline incision for patients with an eyebrow-to-hairline distance greater than 5 cm. Debate continues regarding whether to bevel the incision parallel or perpendicular to the hair follicles to produce the best cosmetic result. Camirand\textsuperscript{83} and Camirand and Doucet\textsuperscript{84} compared the two beveling techniques and found that the incisions that were oriented perpendicular to the hair follicles were superior based on invisibility of the scar, nonlinearity of the scar, absence of hypopigmentation, and presence of hair in front of the scar. The hair follicles of the anterior temporal hairline grow anteriorly and inferiorly at an angle of 7 to 27 degrees (mean, 16 degrees) to the epidermis.\textsuperscript{85} Pollock and Pollock\textsuperscript{86} reported performing a hairline subcutaneous brow lift that results in acceptable scars by beveling the incision perpendicular to the hair follicles. Guyuron and Rowe\textsuperscript{87} described the use of a hairline incision combined with posterior scalp advancement to shorten a long forehead during brow lift.

Temporal

Temporal brow lifting is one of the oldest known methods for repositioning the brow, dating to Passot in 1919.\textsuperscript{3} Gleason\textsuperscript{88} performed brow lift by extensive subcutaneous undermining in the temporal and lateral orbital areas up to the anterior branch of the temporal artery, at which point the dissection deepened to a subgaleal plane. The incisions were not connected across the midline. Ten of 102 patients developed transient temporal alopecia, and one patient experienced temporary frontal paresis. Dingman\textsuperscript{89} described another modification of the temporal lift that involved initial dissection in a subgaleal plane.

Byrd\textsuperscript{90} and Byrd and Andochick\textsuperscript{91} described a temporal approach that involves dissection in the subgaleal plane with extensive soft-tissue release at the superior and lateral orbital rim. Further dissection over the zygomatic arch below the superficial layer of the deep temporal fascia allows elevation of the malar fat pad and avoids the temporal branch of the facial nerve.

Several authors\textsuperscript{92,93} have reported using a biplanar temporal lift to improve lateral brow elevation. Marshak et al.\textsuperscript{95} described a temporal incision and then creation of an SMAS-galeal flap to increase the amount of lift. Fogli\textsuperscript{96} described beginning his dissection in the subgaleal plane and then transitioning to the subcutaneous plane just anterior to the hairline.

Endoscopic

The endoscopic approach allows access to the forehead for release of the retaining structures of the upper face and for muscle resection through very small incisions in the scalp. Use of the endoscope in forehead surgery was first presented by Isse\textsuperscript{12} and by Vasconez\textsuperscript{12} in 1992 and by Hamas\textsuperscript{94} in 1993. Steinsapir et al.\textsuperscript{95} reviewed the anatomy and surgical technique of endoscopic forehead lift. Excellent descriptions of that technique can be found in articles and chapters by Aiache, Daniel and Tirkanits, DeCordier et al., Guyuron, Rowe and Guyuron, Isse, and Nahai. Vasconez et al.\textsuperscript{101} presented the results of a series of brow lifts performed in 32 patients. A subperiosteal approach was used, with subgaleal dissection down to the orbital rims, corrugator and procerus resection, and frontalis scoring. Fixation was by bone-soft tissue anchors or by sutures connecting the galea to the temporalis fascia. The authors reported moderate lifting of the brow in most cases. Complications included perforation and burning of the forehead, temporary palsy of the temporal nerve, and three cases of glabellar hematoma.

Sozer and Biggs\textsuperscript{102} reviewed 128 endoscopic forehead lifts performed in a subperiosteal plane. Their operative time was 15 to 30 min. A common complication was local alopecia, which decreased in frequency when the authors began using fixation with titanium microscrews. Two patients had asymmetrical brow position. The lift effect persisted for the 5 years of follow-up.

Hamas\textsuperscript{103} reported limiting his technique to resection of the corrugator and procerus muscles to reduce prominent glabellar frown lines. In his series of 35 patients, approximately 50% of glabellar wrinkles on maximal effort were reduced. Complications included a noticeable depression in the glabellar region in the first few patients and one patient with a skin burn.

Hamas and Rohrich\textsuperscript{104} presented a technique whereby the galea aponeurosis is plicated after separating it from the forehead skin above and below the scalp incision. The modification effectively raises
the central brow without elevating the central hairline.

Other contributions to endoscopic foreheadplasty have been made by Isse,24 Aiache,26 Ramirez,105 and Chajchir.106 Since those authors presented their reports in 1994, long-term follow-up results have been presented by multiple authors.98,99,107,108 The results have been long lasting and stable.

Limited Incision

Several authors have reported using endoscopic brow lift-type incisions in the hairline to raise the lateral eyebrow through a limited incision. Kikkawa et al.109 reported using small scalp and upper eyelid blepharoplasty incisions to dissect the lateral brow in a subperiosteal plane and to resect the corrugator and procerus muscles.

Knize110,111 described limited-incision foreheadplasty, with lateral dissection of the lateral brow in a subperiosteal plane. The author emphasized that the dissection must include release of the periosteal attachments along the superior orbital rim and transection of the ligamentous band that he calls the orbital ligament (Fig. 16). A transpalpebral approach is taken to the procerus and corrugator musculature (Fig. 17).110,111 In a discussion of the articles presented by Knize, Rohrich112 offered an algorithm for correction of the aging forehead and periorbital area (Fig. 18).

Limited incision non-endoscopic techniques have gained popularity. Their biggest advantage over the endoscopic approach is the avoidance of cumbersome and expensive equipment.113 A non-endoscopic limited approach can be safely performed with mastery of the regional anatomy.114 Medial brow elevation can be minimized or avoided with a limited incision technique. A transpalpebral route can be used in conjunction with a limited incision technique for corrugator resection.

Plane of Dissection

Subcutaneous

A subcutaneous brow lift has the advantages of a direct approach to removing transverse wrinkles of the forehead and for elevating the brow while preserving sensation to the scalp posterior to the incision. The disadvantage of the technique is a significant decrease in flap vascularity, which was responsible for high rates of complications in several series.78,115,116 Rees and Wood-Smith115 and Ortiz-Monasterio et al.78 listed potential problems with the subcutaneous brow lift, such as alopecia, wound dehiscence, skin slough, poor scars, anesthesia of the forehead, and compromised circulation. Guyuron116 also reported a higher complication rate with the subcutaneous brow lift than with other methods of rejuvenating the forehead.

In contrast, Wolfe and Baird117 presented their experience with subcutaneous brow lift in 27 women and reported no significant loss of tissue or hair. The authors recommended the procedure for older patients who have considerable transverse and vertical wrinkling or pronounced brow ptosis. Not long ago, Wolfe118 reviewed his indications for subcutaneous forehead lift, as follows:

• very wrinkled forehead with pronounced brow ptosis, particularly laterally
• secondary or tertiary forehead lift
• very short forehead that needs heightening
• high forehead that needs shortening by advancing a scalp flap

The author’s routine forehead lift is still a subgaleal dissection through a coronal incision. Complications occurring in several dozen patients included a small

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**Figure 16.** Eyebrow elevation through small incision in scalp. Subperiosteal forehead flap is raised and orbital ligament (*) transected for maximum upward movement of superficial temporal fascia. STF, superficial temporal fascia; TL, temporal fusion line of the skull; div., division; n., nerve. (Reprinted with permission from Knize.110)
Figure 17. Technique of limited incision foreheadplasty through transpalpebral approach. n., nerve. (Reprinted with permission from Knize.111)

Figure 18. Algorithm for treatment of forehead wrinkles. (Modified from Rohrich.112)

* Correction of the static frown lines is done with simultaneous laserabrasion with CO₂, or combined erbium and CO₂ laserabrasion.
subcutaneous ecchymosis and one case of cutaneous hypersensitivity of the lateral brow and temporal area that persisted for more than a year.

Guyuron\textsuperscript{116} asserted that a subcutaneous plane is more effective than other methods for eliminating forehead wrinkles and crow’s feet. With that approach, the surgeon has the option of shortening or lengthening the forehead or leaving the length unchanged. Vogel and Hoopes\textsuperscript{119} presented a report of 50 patients who underwent subcutaneous brow lift with few complications. The main disadvantage of that technique is the precision required for the incision and closure and the time-consuming dissection.

Miller et al.\textsuperscript{120} reviewed the pros and cons of subcutaneous brow lift and interbrow muscle resection through an incision in the lateral temporal hairline. An additional benefit of that approach is the ability to excise some of the non-hair-bearing skin, thereby decreasing temporal baldness. The authors reported minimal complications in 65 patients.

Pollock and Pollock\textsuperscript{86} reported that the subcutaneous lift provides the most direct approach to elevation of the ptotic bow, which is a skin appendage. The ratio of advancement to lift is 1:1. Corrugator resection is performed by incising the galea transversely in the glabellar region. Flap advancement is secured by using progressive tension sutures to hold the brow in position. In their series of 80 patients, only one patient had transient epidermolysis in the temporal scalp resulting in a small area of alopecia.

Subgaleal
Rudolph and Miller\textsuperscript{121} reported that the subgaleal dissection is rapid, considering the plane is obvious and safe, and that it facilitates direct resection of muscle without nerve damage. Connell and Marten\textsuperscript{76} stated that they use that plane because it is relatively bloodless, is easy to identify and dissect, and offers excellent access to hypertrophied muscles. Ramirez\textsuperscript{122} reported that by elevating the rigid pericranium, the skin is not allowed to stretch in cases of severe fixed forehead wrinkles. Connell and Marten,\textsuperscript{76} Vinas et al.,\textsuperscript{10} and Ortiz-Monasterio et al.\textsuperscript{29} all reported series in which a subgaleal flap was effectively used, and De La Plaza et al.\textsuperscript{123} suggested that the galea adheres more rapidly to peristomeum than does peristomeum to bone, resulting in surer fixation of the tissues.

Knize\textsuperscript{23} stated that the majority of eyebrow movement occurs between the leaves of the galea at the orbital rim. Dissection in that plane is likely to result in the greatest degree of translation of the brow. Byrd and Andochick\textsuperscript{91} reported performing their temporal lift in the subgaleal plane, freeing the attachments of the orbicularis to the peristomeum. Dissection can initially begin in the subgaleal plane and transition to the subperiosteal plane 2 cm above the orbital rim.

Troilius\textsuperscript{124} compared the surgical outcome of subgaleal and subperiosteal brow lifts in 120 patients. Measurements were obtained from preoperative photographs and compared with postoperative measurements at 1 year. The data were analyzed by means of a digitalized analyzing tool. Patients who had undergone subgaleal brow lift showed no significant elevation of the brow after 1 year, whereas patients who had undergone subperiosteal brow lift showed a mean increase in vertical brow height of 7 mm. In a discussion of the article by Troilius, Stuzin and Rohrich\textsuperscript{125} attributed the lack of persistent improvement in the subgaleal series to many factors, such as method of fixation (Troilius did not use anchor fixation), incision position (mostly coronal rather than hairline), skin versus galea excess (a subcutaneous technique might be indicated for older patients with brow skin laxity), and the dynamic forces of orbicularis oculi contraction on a daily basis (which should be counteracted with botulinum toxin injections).

Subperiosteal
Ramirez\textsuperscript{122} reported that lifting the inelastic pericranium produces more effective traction over the brows. The theory is that a more natural gliding of the forehead tissues can be obtained by preserving the subgaleal fascia in the interface between the frontalis muscle and the pericranium. McKinney\textsuperscript{126} noted that advocates of this plane of dissection think a more solid elevation is attained when the peristomeum sticks to the bone. This, therefore, has been the preferred plane of dissection of most practitioners of endoscopic brow lift. The arcus marginalis must be released for effective elevation.\textsuperscript{122} de la Paza and de la Cruz\textsuperscript{127} cautioned that the peristomeum is the sole nutrient
source of membranous bones and that its removal could hasten the resorption of the facial skeleton that occurs with age.

**Combined Subcutaneous and Subperiosteal**
The main advantage of the subcutaneous approach is that it preserves sensation posterior to the incision line. The subperiosteal approach, on the other hand, allows better periorbital remodeling. Ramirez combined the two approaches in a biplanar dissection through the endoscope that maximizes the advantages and minimizes the disadvantages of either method alone (Fig. 19).

Hamas and Rohrich stated that the combined subcutaneous and subperiosteal approach allows brow lifting without elevation of the central forehead.

**Subgaleal versus Subperiosteal**
Thomas et al. compared the strength of subgaleal versus subperiosteal flap adherence in a rabbit model. They found that the subgaleal flap strength exceeded that of the subperiosteal flap at all time points. Additionally, the subgaleal flap regained preoperative strength at 2 weeks, compared with the subperiosteal flap at 8 weeks. Early and rapid readherence is noted in the subgaleal plane compared with the subperiosteal plane in a rabbit. Microscopic analysis at 4 weeks showed less intervening space and greater connective tissue proliferation in the subgaleal flap.

Although this suggests that subgaleal dissection might provide some advantages over the subperiosteal approach, the exact clinical implications require further investigation. Boutros et al. examined the temporal sequence of periosteal readherence in guinea pigs. They found that meaningful strength was regained by 30 days. The rate of healing and the accumulation of wound strength approximated that of other types of wounds. The two studies might have implications regarding the type and duration of stable fixation required during the postoperative period.

**Method of Fixation**
Traditionally, brow elevation has been maintained by excising skin. Ortiz-Monasterio proposed guidelines for the removal of skin during brow lift. The author recommended a 2:1 ratio of skin resection to brow elevation and 3:1 when frontalis muscle is removed. Flowers et al. and Flowers and Ceydeli, on the other hand, stated that a ratio of 4:1 or 5:1 is required to produce a long-lasting effect. Aggressive skin excision however, can cause many secondary wound problems, particularly when the frontalis has been resected.

Rohrich and Beran reviewed methods of endoscopic fixation for brow lift procedures. Skin excision has been adapted to the endoscopic technique by the Emory group with their V-to-Y closure. Other methods have relied on compressive dressings while the surgical planes “bond.” Microscrew fixation has been used by Daniel and Tirkanitis. Fiala and Owsley used Mitek anchors. Guyuron used a combination of fascial sutures and bone tunnels for suture fixation. Swift et al., Walden et al., and McKinney and Sweis used cortical tunnels. Isse suspended the temporalis fascia to the deep temporal fascia and between the periosteum and the bone by tunneling or applying microscrews. Jones and Grover achieved significantly more stable results with polydioxanone suture than with fibrin glue. Kobienia and Van Beek burrowed an upside-down U-shaped trough in the outer calvaria around which the suspension suture is hooked. Others have presented different variations of fixation involving soft-tissue imbrication and suspension sutures acting as cables all the way to the brow dermis. Troilius stated that no fixation is needed when the goal of brow elevation is 4 mm or less.
Significant interest has been shown in the use of bioabsorbable screws and multipoint fixation devices. Both Eppley and Morello reported achieving adequate fixation with bioabsorbable screws. Coapt Systems (Palo Alto, CA) has developed bioabsorbable multipoint fixation devices (Endotine and Ultratine) for use with endoscopic brow lift.

Walden et al. investigated the safety of different methods of invasive brow fixation. The authors compared techniques that used Mitek anchors, cortical tunnels, Endotine fixation devices, and miniscrews. All techniques were performed on fresh cadavers as described in the literature or per manufacturer recommendations. No instance of inner table penetration was seen with cortical tunnels or with Mitek anchors. One Endotine post penetrated the inner table, and three miniscrews penetrated the inner table. Relative contraindications to invasive brow fixation include any pathological condition of bone, including severe osteoporosis, cystic changes of hyperparathyroidism, Paget disease, osteopenia or osteomalacia, osteonecrosis, previous fracture, or previous surgery.

Endoscopic versus Coronal versus Transpalpebral Techniques
The literature abounds with opinions regarding the various surgical approaches, but very little objective data are available for comparison. Dayan et al. retrospectively evaluated the results of different techniques to determine whether endoscopically assisted procedures achieve the same degree of correction as do coronal techniques. The authors studied the effects of concurrent blepharoplasty on brow elevation and assessed the long-term outcomes after coronal lifts (but not endoscopically assisted lifts). The authors concluded that in their study group, both methods achieved similar brow elevation at 1 year, concomitant blepharoplasty had no significant effect on brow elevation, and coronal lifts were associated with a gradual drop in brow elevation over 5 years.

In a recent study, Walden et al. compared the efficacy of corrugator resection between transpalpebral and endoscopic techniques in 24 anatomic dissections. The authors found that the endoscopic approach facilitated visualization, and thus more complete resection, than did the transpalpebral technique, which failed to remove up to one-third of the transverse head of the corrugator muscle. Guyuron, however, countered with his experience in achieving complete corrugator resection when using his transpalpebral technique.

Chiu and Baker examined the usefulness of endoscopic brow lift over a 5-year period. The authors found a 70% decline in the number of endoscopic brow lifts performed at their hospital. A survey queried the plastic surgeons at that hospital about the decline and showed that 48% thought the selection criteria for endoscopic brow lift candidates were more limited, 35% thought other techniques were equally or more effective, and 35% thought that endoscopic brow lift does not work in the majority of patients. Although 70% of patients were satisfied with their results, only half of plastic surgeons were happy with the long-term results.

Elkwood et al. conducted a national survey to assess trends in brow lifting techniques. Approximately equal numbers of coronal brow lifts and endoscopic brow lifts were performed. Plastic surgeons generally found the open approach to be more effective for brow elevation, forehead wrinkle elimination, and eradication of glabellar frown lines. Younger practitioners were more likely to use newer technologies.
OTHER ISSUES

Combined Procedures

Brow lifting commonly is performed in conjunction with other procedures for balanced facial rejuvenation. Although the combinations are virtually endless, several common combinations deserve special mention.

Brow lift often is performed in conjunction with periorbital rejuvenation. It is critical to position the brow in its anticipated postsurgical position for accurate evaluation of the upper eyelid. Upper blepharoplasty skin excision tends to be less aggressive when performed with brow lift.

Stuzin described his approach to endoscopic brow lift, upper and lower blepharoplasty, and retinacular canthopexy. He reported using the endoscope predominantly for dissection along the temporal line of fusion between the frontal bone and temporalis muscle to help protect the temporal branch of the facial nerve. Corrugator resection and subperiosteal forehead dissection are still performed through the transpalpebral approach. The lower lid is addressed with a skin flap and canthal repositioning and/or tightening.

When performing an endoscopic brow lift, the dissection can proceed carefully down into the midface for combined upper and midface rejuvenation. After mobilization of the brow, Byrd and Andochick and Hunt and Byrd approached the midface through a sub-SMAS approach, following the superficial layer of the deep temporal fascia over the zygomatic arch and into the midface. Fascial fixation and suspension sutures and microscrews are used. Hobart and Flood performed a subperiosteal midface lift in conjunction with an endoscopic brow lift. Combining the forehead and the midface lift can have favorable effects on lower eyelid aesthetics by decreasing the vertical height of the lower eyelid, lessening infraorbital hollowing, and improving dermatochalasis.

Modification of the Upper Facial Skeleton

The bony characteristics of the forehead often differentiate men from women. The male forehead has extensive supraorbital bossing with a continuous mild curvature. Departures from these anthropometric norms can affect forehead and brow aesthetics. Others have noted excessive down slanting of the supraorbital ridges as contributing to a “sad look.”

Access to the forehead and periorbital area is achieved through a coronal scalp incision. For limited contouring isolated to the supraorbital rim, an upper lid approach can be used. Ousterhout divided patients into three groups: group 1 can be treated through bony contouring alone, group 2 requires bony contouring in conjunction with methyl methacrylate cranioplasty, and group 3 requires extensive modification with osteotomies.

Recontouring the frontal bone and supraorbital ridge is best achieved with a burr, obtaining a controlled graduated resection. The orbital rim can be contoured with a burr or an osteotome. Augmentation can be achieved with bone grafts, synthetic materials, or pericranial or other soft tissue flaps. Pitfalls include entering the frontal sinus and other complications inherent to craniofacial surgery or periorbital aesthetic surgery.

Forehead Wrinkling

The issue of which management approach includes the most modification of forehead wrinkles remains controversial. Flowers et al., Ramirez, and McKinney do not favor resection of the frontalis muscle, reasoning that frontalis hypertrophy from brow ptosis causes the rhytids and that elevating the brow will decrease frontalis activity.

Numerous authors have emphasized the importance of surgical manipulation of the frontalis muscle to decrease muscle hypertrophy. Marino stated that he prefers horizontal incision of the frontalis without muscle excision to decrease the tendency of the subcutaneous tissue to adhere to the galea at the site of muscle resection. Pitanguy advocated vertical and horizontal incisions of the aponeurosis.

Vinas et al. and Kaye recommended excision of a strip of frontalis across the midforehead (beneath the area of maximum transverse wrinkling) while maintaining intact frontalis in the suprabrow area to
preserve normal upper facial expression. LeRoux and Jones\textsuperscript{158} reported excision of the entire frontalis muscle in 71 patients. Botulinum toxin type A (Botox) has also been used in the treatment of dynamic rhytids in the forehead.\textsuperscript{159}

**Glabellar Wrinkling**

Vertical rhytids of the glabella area are caused by corrugator activity. Transverse rhytids at the nasal root are caused by the procerus muscle. Selective surgical interruption of the nerves to the muscles has been suggested by Castanares\textsuperscript{59} and by Bames,\textsuperscript{160} whereas other authors\textsuperscript{1,10,78} have advocated muscle division or segmental resection through either an endoscopic\textsuperscript{24,161,162} or a transpalpebral\textsuperscript{70,71} approach.

Guyuron and Rose\textsuperscript{163} used a fat graft harvested from the infratemporal fossa to pad the glabellar space during forehead and/or brow rejuvenation. According to the authors, the fat graft prevents contour deformities after muscle resection, restores a more "rejuvenated contour," and helps prevent recurrence from reattachment of the residual muscle to itself or to the underlying bone. The authors reported no adverse consequences associated with the maneuver performed in 74 patients.

Glabellar wrinkles can also be temporarily corrected by intramuscular injection of botulinum toxin. Keen et al.\textsuperscript{164} showed the efficacy of botulinum toxin in 11 patients. Electromyographic tracings were used to pinpoint the site of injection. The onset of action was 3 to 5 days, and the duration of action was approximately 6 months. Botulinum toxin injection is now well established as an adjunct to brow lift surgery for the treatment of glabellar furrows and lateral crow’s feet.\textsuperscript{164-167} Patient satisfaction with Botox treatment is consistently high, and patient-reported outcomes have indicated significant improvement in recent years.\textsuperscript{168,169}

**Chemical and Liquid Brow Lift**

Botox can also be used to perform a "chemical brow lift" through selective muscle weakening, which is known as chemodenervation.\textsuperscript{165-167,170,171} The chemical brow lift can be used to target the medial brow, lateral brow, or both. Although the lifting effect is temporary, improved cosmesis has been reported. Frankel and Kamer\textsuperscript{165} reported performing chemical brow lift by injection of 20 units of Botox into the procerus and corrugator supercilii in 29 patients, 18 (62\%) of whom showed higher medial brows after treatment. Fifty-nine percent of patients also showed an increase in interbrow distance. Huang et al.\textsuperscript{167} reported accomplishing temporary brow lift with botulinum toxin in 11 women. The authors injected 5 units into the glabella and 10 units along the lateral orbital rim. The largest mean elevations (approximately 2.5 mm) were noted in the central brow area.

Ahn et al.\textsuperscript{166} injected 7 to 10 units of Botox directly into the lateral orbicularis oculi to elevate the lateral brow a mean 4.83 mm (Fig. 21). The elevation persisted for 3 to 4 months in all 22 patients. Mild bruising was reported in five patients and minimal transient eyelid ptosis in two. Guyuron\textsuperscript{167} noted that 7 to 10 units might be insufficient for achieving a lasting result. The author subsequently noted an age-dependent response, with younger patients having more elevation than older patients. The technique presented by Guyuron was further modified by Maas and Kim,\textsuperscript{173} with smaller target doses being administered in the frontalis (12–16 units) and increased doses in the superolateral brow area (16–20 units).

![Figure 21. Botox injection sites (x) into lateral portion of orbicularis oculi muscle. Subsequent unopposed frontalis muscle activity results in lateral brow elevation. (Reprinted with permission from Ahn et al.\textsuperscript{166})](image-url)  

Carruthers and Carruthers\textsuperscript{71} were able to obtain lateral brow elevation with only a glabellar injection.
of Botox. Lateral brow elevation was almost immediate, and then central and medial brow elevation peaked at 12 weeks after treatment. The authors postulated that the diffusion of Botox to the medial frontalis caused an increased resting tone in the remainder of the muscle. They also noted that the minimal amount needed in the glabellar region to obtain lifting of the brow was 20 units.

New trends indicate a combination of Botox with fillers to further sculpt the brow. The combination of volume restoration and alteration of muscle balance can enhance the results. Kane\textsuperscript{174} and the Facial Aesthetics Consensus Group Faculty\textsuperscript{159} used this technique.

Ciuci and Obagi\textsuperscript{175} used autologous fat transfer for rejuvenation of the periorbital complex. With that method, fat is injected to provide for volume restoration, achieving a full upper brow, decreased skin laxity, and camouflaged supraorbital and infraorbital rim.

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