

A Reappraisal of Surgical Techniques and Efficacy in Forehead Rejuvenation

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Summary: Forehead rejuvenation has an essential role in overall facial rejuvenation. Despite the evolution of rejuvenation techniques, principles of forehead rejuvenation remain the same. Circumspect facial analysis provides a crucial foundation in selecting the appropriate surgical technique and in optimizing the final aesthetic outcome. Today, myriad surgical options exist to address the senescent forehead. For example, the procedure can be performed through open, coronal, pretrichial, limited, or endoscopic incisions. The goal of this review article is to provide a simple and systemic approach to forehead rejuvenation. Common components of an aging forehead are reviewed. For each problem, a reappraisal of indications and efficacy of available surgical options is suggested. Of note, elevation of eyebrows on patients who have eyelid ptosis, proptosis, or deep tarsal crease should be avoided or carried out conservatively. It should often be performed in conjunction with ptosis correction and fat injection to the hollowed upper eyelid. On men with a receding hairline, the corrugator supercilii muscles are removed through the transpalpebral approach and the temple is lifted through two radial incisions and endoscopic dissection. (*Plast. Reconstr. Surg.* 134: 426, 2014.)

Forehead rejuvenation is a constantly changing field. Surgical techniques evolve with developing technologies. The newer minimally invasive techniques aim to reduce the morbidity of the procedure by decreasing the size of the incision, reducing postoperative numbness, and minimizing the risk for alopecia. Unlike the ever-changing surgical techniques, the characteristics of an aesthetically pleasing forehead have remained constant. A youthful forehead should be smooth and without lines. The length is harmonious with the rest of the face: the distance from the hairline to the eyebrows is approximately one-third of the total length of the face. In most individuals, the upper border of the eyebrow should be greater than 2.5 cm above the mid-pupil level on straight gaze. The medial eyebrow is caudal to the lateral eyebrow. The contour of the forehead on profile should be smooth and without bossing or depression. The youthful glabella is slightly projected and flattens with senescence.^{1,2}

Detailed analysis of the forehead preoperatively is critical to the choice of surgical techniques and the final outcome. For example, a patient

with an elongated forehead may benefit from a pretrichial incision.³ Wrinkles secondary to frontalis muscle activation to compensate for eyelid ptosis warrant a different treatment plan than wrinkles created by hyperactive frontalis muscles underneath a thinning skin or wrinkles caused by overactive corrugator supercilii and/or depressor supercilii muscles. While assessing the eyebrow position, steps should be taken to deactivate the frontalis muscle to accurately determine the eyebrow and eyelid position. Eyebrow repositioning is essential in forehead rejuvenation. Multiple studies have described the ideal brow position. In individuals with a full upper eyelid, the distance from the upper border of the brow to the mid pupil on straight gaze should be at least 2.5 cm.¹ This distance may not appear optimal on someone who has a hollow upper eyelid or a prominent globe. The medial end of the ideal female brow should be caudal to the lateral brow.⁴ The medial eyebrow should be in line with the lateral ala. The highest portion of the eyebrow arch should lie over the lateral limbus, and the lateral eyebrow should fall in a line connecting the lateral canthus and the lateral ala.⁵ In most instances, the eyebrow arches above the supraorbital rim in women. In men, the brow

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ideally is at the level of the supraorbital rim and the arch is flatter.^{6,7} Multiple archetypes on the ideal eyebrow position and shape have been proposed. Current trends in eyebrow shape favor a more lateral brow apex. Younger patients were shown to prefer a more lateral brow apex. Older patients, in contrast, preferred a more medial apex.⁴ Despite the debate in the literature regarding the “best” brow position and shape, Hamamoto et al. have shown that no single brow design stands out as the best in optimizing overall facial attractiveness. Each archetype can be used effectively in achieving a superior brow position.⁸ Although trends in brow shape change, few will argue that the lateral brow should be higher than the medial brow, because lateral brow ptosis is a hallmark of forehead aging.

It is absolutely essential to include animated views of the forehead in preoperative and postoperative assessment of forehead rejuvenation patients. Although the forehead may appear perfect in repose, animation may disclose a variety of flaws ranging from minor to major deformities. Our team has not published a forehead rejuvenation report without preoperative and postoperative animated views for decades, and we hope that the other authors can follow this principle and that this can become an accepted standard.

The goal of this article is to review the role and efficacy of various surgical techniques in addressing common problems seen in an aging forehead. Although nonsurgical techniques such as lasers and injection of botulinum toxin and fillers are important in forehead rejuvenation, they will not be discussed in this article.

PROBLEM 1: FOREHEAD LENGTH DISHARMONY

The ideal length of the forehead—hairline to the eyebrows—is approximately one-third of

the total length of the face, and it usually measures approximately 6 cm.² The forehead may be elongated secondary to congenital, aging, or iatrogenic causes such as previous coronal incisions or endoscopic foreheadplasty with central fixation. The degree of elongation can be classified as minimal (<5 mm of excess), mild to moderate (5 to 10 mm of excess), or severe (>10 mm of excess). For patients with minimal or no forehead elongation, endoscopic access to the forehead is preferred in our practice. For patients with mild to moderate elongation, a pretrichial incision and subsequent subcutaneous or subgaleal dissection and skin excision is ideal. Our group demonstrated the effectiveness of this procedure in two separate studies^{9,10} (Fig. 1). In 1998, 172 patients who underwent forehead rejuvenation with a pretrichial incision were reviewed. Average follow-up was 6.56 years. All patients were satisfied with the result. Complications included temporary hair loss in one patient and delayed wound healing in three patients requiring scar revision.¹¹ Two hundred ninety-seven patients who underwent forehead rejuvenation from 1998 to 2007 with a pretrichial incision were also reviewed. Average follow-up was 1 to 8 years. All patients were satisfied with the result. Complications included delayed wound healing in six patients.³

For a severely elongated forehead (>10 mm of excess), a posterior scalp advancement flap is recommended. The senior author (B.G.) described a technique where the forehead is shortened by advancing the posterior scalp and lowering the hairline.³ A curvilinear pretrichial incision is made and the scalp is undermined to the occipital region. Scoring of the galea is performed and the scalp is repositioned anteriorly. Depending on the advancement necessary, the galeal fascia of the scalp flap is secured to the cranial bone in a more anterior position using 3-0 polydioxanone sutures

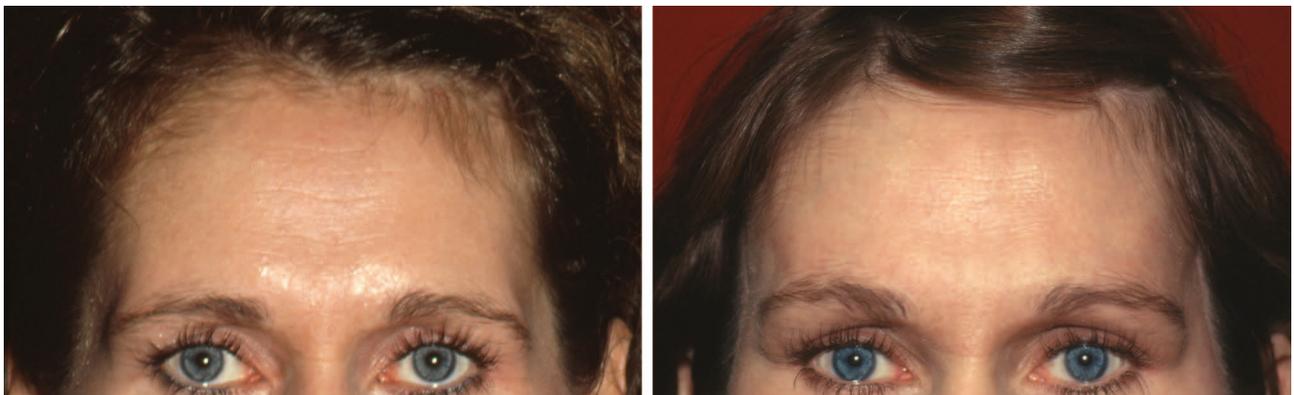


Fig. 1. A patient before (left) and 7 years after (right) a subcutaneous forehead lift with a pretrichial incision.



Fig. 2. A patient before (*above, left*) and 1 year after (*above, right*) a posterior scalp advancement flap for forehead shortening. The same patient is shown before (*below, left*) and 1 year after surgery (*below, right*) on animation.

in one to three rows. The non-hair-bearing skin is then trimmed for a tension-free repair³ (Fig. 2). In 20 patients who underwent scalp advancement using this method, our group observed three cases of alopecia and one case of delayed wound healing.¹¹ The incidence of alopecia can be reduced or completely eliminated by avoiding the injection of solutions containing 1:100,000 epinephrine in the hair-bearing scalp. Significant advancement on current or previous heavy smokers should be avoided. Marten reviewed 27 patients who underwent the forehead shortening and scalp advancement procedure without fixation and in whom a high degree of patient satisfaction was achieved. Complications included one patient with seroma formation, one patient with scalp paresthesias, and one patient with delayed wound healing. We prefer fixation of the anteriorly advanced scalp flap because of concern for potential posterior migration of the scalp. Over time, this may result in unintended lifting of the central eyebrows.¹² Ramirez et al. reviewed 29 patients who underwent trichophytic incision and posterior scalp advancement, with follow-up ranging from 1 month to 8 years. All patients reported high satisfaction rates with the procedure. Average

advancement of the anterior hairline was 2.1 cm. Complications included two patients with hair loss and one patient with delayed wound healing.¹³

Not only is it important to consider forehead length in selecting the type of rejuvenation approach, it is also critical to understand the effects of the surgical approach on the hairline. Our group reviewed the long-term effect of the type of incision on the hairline in 31 patients (17 endoscopic and 14 open with pretrichial incision). The pretrichial incision was found to result in a statistically significant stability of the hairline position over time (up to 8 years) without any hairline recession compared with the endoscopic and control groups. In contrast, the endoscopic and control groups demonstrated naturally anticipated hairline recession.¹⁴ This study suggests that pretrichial incision has the capability to cease the expected or excessive hair loss.

PROBLEM 2: FOREHEAD CONTOUR. GLABELLA FLATTENING AND FOREHEAD VOLUME LOSS AND FRONTAL BOSSING

Forehead skin and subcutaneous tissues undergo significant atrophy with time. This

contributes to the development of glabellar flattening and even depression and formation of wrinkles. On profile, the female glabella area should be slightly convex in an ideal forehead. Loss of subcutaneous tissue often levels or reverses this convexity. Lipofilling, used either alone or in conjunction with a forehead lift, improves the outcome of forehead rejuvenation. Fat not only is a natural filler but has also been shown in an animal model to stimulate neosynthesis of collagen and increase the thickness of the overlying skin.^{15,16} Fat can be grafted macroscopically with or without the dermis, or through microinjection.¹⁷ The glabella is unique in that when the corrugator supercilii muscles are intact, fat graft take is suboptimal. However, if the underlying muscle has been deactivated either surgically or chemically, higher retention rates of grafted fat are achieved. Overcorrection is then not necessary.¹⁸ Isik and Sahin reviewed forehead contour restoration through lipofilling in nine patients. Follow-up time was 1 to 2 years. All patients were satisfied with the results and showed good retention of the fat grafts and better overlying skin quality. No complications were noted, with the exception of one patient who required repeated lipofilling.¹⁹ Our experience has been similar (Fig. 3). In all of our patients who undergo endoscopic resection of corrugator supercilii and depressor supercilii for either forehead rejuvenation or migraine I surgery (frontal migraine headaches), fat without dermis was harvested from above the zygomatic arch and deep to the temporal fascia endoscopically.²⁰ The fat was then placed in the glabella region to replace the muscle. When a transpalpebral approach was used, redundant nasal compartment fat pad was used to replace the removed glabellar muscles. Otherwise, fat injection using conventional lipotransfer technique will provide the same pleasing outcome. Autologous fat grafting is a safe and

effective procedure in volume restoration, with minimal morbidity. Rare complications include overfilling and underfilling.²¹

Similar to forehead contour flattening, frontal bossing results in an equally unattractive, harsh, and stern forehead appearance. In female patients, frontal bossing masculinizes the facial skeleton.²² Frontal bossing can result from a variety of causes. However, hyperaeration of the frontal sinus is commonly seen in this patient population. For those with adequate anterior frontal sinus bone thickness and mild to moderate bossing, an endoscopic approach to shaving down the frontal bone is safe and effective. This procedure can be performed in conjunction with endoscopic brow lift or as an isolated procedure.²³

PROBLEM 3: FOREHEAD RHYTIDES

The formation of forehead rhytides is an integral part of aging but is not expected on every individual. Understanding the cause of forehead rhytide formation allows for appropriate treatment plan selection.

Overactive Frontalis Muscle and Eyelid Ptosis

Eyelid ptosis is commonly seen in patients with prominent horizontal forehead rhytides. Patients subconsciously recruit the frontalis muscle to aid eyelid opening by raising the eyebrows. To prevent this compensation, the examiner may ask the patient to close his or her eyes tightly and open them slowly just enough to view the examiner's face. This maneuver deactivates the frontalis and unmasks potential eyelid ptosis. Lifting the forehead without recognizing and informing the patient of the preoperative eyelid ptosis or proptosis may have displeasing consequences because lifting the forehead will exaggerate the visibility of the deepened supratarsal crease caused by eyelid



Fig. 3. A patient before (left) and 2 years after (right) lipofilling of the forehead.

ptosis and preexisting proptosis. The horizontal lines caused by overactive frontalis musculature can be softened by thinning the frontalis muscle from the deep surface of the forehead flap during open or endoscopic forehead lift. It can also be cauterized during a subcutaneous forehead lift.^{24,25}

Overactive Corrugator Supercilii and/or Depressor Supercilii Muscles

Contraction of the horizontal head of the corrugator supercilii muscle produces vertical wrinkles, and contraction of the depressor supercilii muscles and cephalic fiber of the corrugator supercilii create oblique wrinkles in the glabella. Alternatively, the glabellar complex can be removed completely. Resection of the corrugator supercilii and depressor supercilii muscles can be performed through a coronal, open pretrichial, endoscopic, or transpalpebral approach. There is debate in the literature regarding which is the best technique. Walden et al. compared the transpalpebral, endoscopic, and coronal approaches to resecting the corrugator supercilii, depressor supercilii, medial orbicularis, and procerus muscles on 24 sides of 12 cadavers. The group found no significant difference in muscle resection between the coronal approach and the endoscopic approach. However, in the transpalpebral corrugator supercilii resection group, failure to remove up to one-third of the transverse head of the corrugator supercilii muscle occurred.²⁶ A similar study was performed by Afif et al. on 20 sides of 10 fresh cadavers. The group resected the corrugator supercilii muscle through an endoscopic approach on one side of the face and through a transpalpebral approach on the other side. Complete exposure of the area through a coronal incision and muscle weights were used to evaluate for completeness of the resection. The authors found the endoscopic and the transpalpebral techniques to be similar in efficacy in removing the corrugator supercilii muscle.²⁷ There are no comparisons of clinical outcomes in forehead aesthetics after endoscopic versus transpalpebral corrugator supercilii muscle removal. Although forehead aesthetics was not the endpoint of the study, our group did look at the reduction of migraine headaches in patients who have frontal migraine headaches. A critical portion of migraine site I (frontal headaches) surgery is the removal of the corrugator supercilii musculature. Among the 253 patients, 62 underwent transpalpebral corrugator supercilii resection and 191 underwent endoscopic corrugator supercilii resection. The endoscopic group had a significantly higher success rate (89 percent) compared

with the transpalpebral group (79 percent). We agree with Afif et al. that, although it is technically feasible to completely remove the corrugator supercilii through the transpalpebral approach, the endoscope does provide better visibility and magnification. Therefore, we believe the endoscopic approach is slightly more efficacious in completely removing the glabella musculature.²⁸

Of note, complete removal of corrugator supercilii muscles can lead to lateralization of the medial aspect of the eyebrow. This effect, however, is mild and almost invariably a favorable one because an overactive corrugator supercilii muscle pulls the eyebrows too medially and often overcrowds the glabellar area.

Forehead Rhytides

Deep rhytides are best addressed through a subcutaneous forehead lift.⁹ Dissection is carried out in the plane between the subcutaneous tissue and the frontalis muscle. This plane allows for release of the fibrous bands that contribute to the formation of the deep rhytides. In the central forehead, this plane is continued until the most caudal horizontal forehead wrinkle is released. The dissection is then extended deep to the frontalis medially to expose the glabellar musculature for resection.³ In the lateral forehead, the subcutaneous plane of dissection should continue down to the lateral eyebrow. The deep vertical lines can also be treated by undermining on each side of the depressions and adding an autologous fat or superficial musculoaponeurotic system tissue to rejuvenate this area.^{24,29} In patients with significant thinning of the forehead skin, injection of fat within the dermis followed by the subcutaneous lift may produce the best outcome, but this is seldom indicated. Potential complications associated with this approach include alopecia, forehead anesthesia, scar visibility, and skin necrosis. To minimize these complications, the skin flap should be made as thick as possible. This method should be avoided or used with extreme caution in smokers or previous smokers.

PROBLEM 4: EYEBROW PTOSIS

To correct eyebrow ptosis effectively, the forehead flap needs to be fully mobilized by releasing (1) the dense adhesions of the galea and the periosteum medial to the superior temporal fusion line and (2) the orbicularis retaining ligaments/arcus marginalis along the superior and lateral orbital rim. The mobilized flap can then be transposed and fixed to its new position. The release of



Fig. 4. A patient before (*above, left*) and 2 years after (*above, right*) an endoscopic forehead lift. The same patient is shown before (*below, left*) and 2 years after surgery (*below, right*) on animation.

attachments is much more powerful in repositioning the eyebrows than forehead flap fixation.

Exaggerated cephalic repositioning of the brow should be avoided by all means because this change is more harmful to forehead aesthetics than having some eyebrow ptosis. The entire brow can be moved cephalically in an exaggerated fashion without a deleterious effect on forehead aesthetics, provided that the balance between the medial and lateral brow is maintained. It is the exaggerated elevation of the lateral or the medial eyebrow that disturbs the forehead's attractiveness. In this regard, excessive medial brow elevation negatively impacts forehead harmony more so than excessive lateral brow elevation. Medial brow elevation can be minimized by preserving the ligamentous and periosteal attachments to the glabella area. We routinely maintain at least 2 cm of attachment of the periosteum to the glabella in the central forehead.^{30,31} A major trap for the novice surgeon is patients who have proptosis or those with a deep supratarsal crease as a result of eyelid ptosis or naturally exaggerated crease. Elevation of the eyebrows on this group of patients will unmask these unfavorable features. On these patients, elevation of the eyebrows has

to be performed very conservatively. Fat injection to the upper eyelid alone or to both upper and lower eyelids should be strongly considered at the time of the forehead lift to avoid exacerbating the already prominent eyes. Complications to periorbital fat grafting include contour abnormality. The fat should be deposited in a deep plane, and any contour abnormality from the fat deposition should be corrected at the time of surgery. Although rare, blindness has been reported as a result of periorbital fat grafting.³²

The ptotic brow can be repositioned through open, endoscopic, and limited incision techniques. Multiple studies demonstrate the longevity of brow position after endoscopic brow lift. On average, the endoscopic subperiosteal brow lift elevates the brow by 3.5 to 7 mm. Jones and Lo evaluated 31 patients after subperiosteal endoscopic brow lift with cortical bone tunnel fixation (vertical pull above the lateral limbus). The brow was found to be elevated by 3.5 to 4.7 mm at seven measured points at 5.4 years of follow-up. The study also demonstrated that global aesthetic scores improved for 64 percent of the patients 5.4 years after brow lift.³³ Troilius found similar results in 30 patients after subperiosteal



Fig. 5. A patient before (*above, left*) and 1 year after (*above, right*) transpalpebral corrugator supercilii resection. The same patient is shown before (*below, left*) and 1 year after surgery (*below, right*) on animation.

endoscopic brow lift with at least 1-year follow-up. Average brow elevation was 6.7 mm.³⁴ Jones and Grover followed 220 endoscopic brow-lift patients with cortical tunnel fixation with suture for 9.4 months and found an average brow elevation (mid pupil to brow) of 6 mm.³⁵ Our group followed 48 endoscopic brow-lift patients for 1 year. Average elevation was 3.8 mm at the mid pupil and 4.4 mm at the lateral brow³⁶ (Fig. 4). Iblher et al. reviewed 56 endoscopic forehead lift patients with cortical bone fixation followed for up to 5 years. An average of 10 to 15 percent elevation across the whole brow was achieved and maintained.³⁷

The key to successful and efficient endoscopic dissection is finding the optimal plane. This is subperiosteal medially and immediately superficial to the deep temporal fascia laterally. All of the fat superficial to the deep temporal fascia should be elevated with the lateral flap, leaving no fat attached to the deep temporal fascia.³⁸ This plane of dissection ensures safety of the frontal branch of the facial nerve and easy access to the arcus marginalis and the zygomaticotemporal branch of the trigeminal nerve when the operation is intended to treat temporal (site II) migraine headaches.

Limited Incision Procedures

A variety of limited incision techniques with or without corrugator supercilii resection through a transpalpebral approach have been introduced by Knize and others.³⁹ The temple portion of the procedure is carried out through an incision of 2 to 4 cm under direct vision or blindly. The glabella muscles are removed through the eyelid incision. Although the limited incision technique has the advantages of speed and simplicity, the removal of the muscles cannot always be as thorough and the risk of complications is slightly higher because of the blind portion of the surgery.²⁶ Tabatabai and Spinelli compared 100 endoscopic brow-lift patients to 93 limited incision nonendoscopic brow-lift patients. The two groups had similar brow elevation of 4 mm, matching patient satisfaction and complication rates. The nonendoscopic group did have shorter operative time. However, animated views were not used for outcomes assessment, and in our view, this makes the conclusions less reliable.⁴⁰ We prefer the conventional endoscopic dissection. It is safe, rapid, and thorough after the surgeon becomes familiar with the technique. We use a version of this limited technique on men whereby the endoscopic lateral dissection is completed through two 15-mm radial

		Forehead Elongation	Forehead Elongation	Forehead Elongation
		Minimal	Moderate	Severe
Lines	None or Minimal	Endoscopic forehead lift	Pretrichial incision Lateral brow suspension	Pretrichial incision Posterior scalp advancement Lateral brow suspension
	Moderate	Endoscopic forehead lift Glabellar muscle resection or Limited incision and transpalpebral corrugator resection	Pretrichial incision Glabellar muscle resection Lateral brow suspension	Pretrichial incision Glabellar muscle resection Posterior scalp advancement Lateral brow suspension
Lines	Severe	Incision 1-1.5 cm behind the hairline Subcutaneous dissection Glabellar musculature resection	Pretrichial Incision Subcutaneous dissection Glabellar musculature resection Lateral brow suspension	Pretrichial incision Subcutaneous dissection Glabellar muscle resection Posterior scalp advancement Lateral brow suspension
		Minimal	Moderate	Severe
		Brow ptosis	Brow ptosis	Brow ptosis

Fig. 6. Treatment algorithm for a senescent forehead.

incisions in the temples and the corrugator supercilii muscle group is removed through a transpalpebral approach (Fig. 5).

Fixation of the Forehead Flap

The mobilized and elevated forehead flap can be secured through sutures, cortical bone tunnels, and a variety of fixation devices such as Endotine (Coapt Systems, Inc., Palo Alto, Calif.) or fibrin glue. Jones and Grover compared fibrin glue fixation after subperiosteal endoscopic foreheadplasty in 104 patients to 220 patients who had cortical bone tunnel fixation with polydioxanone suture. Followed for up to 6 years, the cortical fixation group was found to maintain significantly more brow elevation compared with the fibrin glue cohort (mid pupil to brow, 3.79 mm).³⁵ In contrast, there is debate regarding whether fixation is necessary at all. One study reviewed 20 patients who underwent subperiosteal endoscopic brow lift with no fixation. At 1-year follow-up, the brow elevation was maintained at 3.9 mm (mid pupil to brow). The author concluded that for brow elevations of

less than 4 mm, scalp fixation is not necessary.⁴¹ Fixation methods are not as critical to maintenance of brow position as wide periosteal dissection and mobilizing the forehead flap from the underlying periorbital retaining ligaments. Removing the glabella muscle group changes the vectors of pull on the eyebrows. The unopposed frontalis naturally elevates the eyebrow.⁴² The only fixation performed by our group is a single-point fixation attaching the superficial temporal fascia to the deep temporal fascia on the majority of patients. Reviewing 48 patients who underwent this procedure, the brow remained elevated (3.8 to 4.4 mm) at 1-year follow-up in a study that our team conducted.³⁶ On patients with significant asymmetry who do not respond to differential release of the attachments alone intraoperatively, we may use a second bone tunnel for fixation through the intermediate incision. No central fixation is ever used.

CONCLUSIONS

Techniques in forehead rejuvenation evolve constantly; however, the principles for achieving

an aesthetically pleasing forehead remain the same. Thorough facial analysis is essential for selecting the appropriate technique. Our algorithm for forehead rejuvenation is shown in Figure 6. Endoscopic forehead rejuvenation is effective for patients with normal forehead length or with minimal forehead elongation. It allows for more complete removal of the glabella musculature and ensures the longevity of brow elevation. Limited incision nonendoscopic forehead lift may offer comparable results to endoscopic rejuvenation in some experienced hands. The open or pretrichial forehead incision is a powerful tool for adjusting forehead length and hairline position. Adequate ligament release and complete glabella muscle resection are more critical for maintenance of brow position than brow fixation techniques. Patients with proptosis and a deep supratarsal crease may require additional care. Lastly, fat grafting or injection is an invaluable companion to forehead rejuvenation.

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PATIENT CONSENT

Patients provided written consent for the use of their images.

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Evidence-Based Medicine: Questions and Answers

Q: Will *PRS* still review, accept, and publish papers with lower levels of evidence?

A: Yes, *PRS* welcomes manuscripts of all Level of Evidence grades and manuscripts that are not amenable to LOE grading. *The LOE grade should be seen dispassionately as a number, a quantitative indicator of the level of evidence in an article.* Papers with lower LOE grades (IV and V) are not “worse” than papers with higher LOE grades (I–III); they simply have data of a different level.

It makes sense that randomized, controlled, blinded, multicenter trials with hundreds or thousands of patients and years of follow-up would have a higher level of evidence than a single author’s experience in a clinical series. However, given the demands of such studies, it also makes sense that there would be few randomized controlled trials but many single-author series or expert opinions. *Such series and expert opinions do have value. PRS welcomes the submission of such papers and will continue to publish them.*

