

Current concepts in the management of the aging forehead in facial plastic surgery

Thomas Romo III^a, Richard A. Zoumalan^b and Benjamin Y. Rafii^b

^aDivision of Facial Plastic and Reconstructive Surgery, Department of Otolaryngology – Lenox Hill Hospital and ^bDepartment of Otolaryngology – Head and Neck Surgery, New York University School of Medicine, New York, USA

Correspondence to Thomas Romo III, MD, Facial Plastic and Reconstructive Surgery, 135 East 74th Street, New York, NY 10021, USA
Tel: +1 212 288 1500; e-mail: docromo@aol.com

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Purpose of review

This article reviews the significant recent literature on the constantly evolving approach to surgical rejuvenation of the forehead and brow.

Recent findings

Recent literature describes a variety of modifications to traditional endoscopic approaches, particularly regarding new permanent and temporary fixation techniques. There is continued effort to deepen our understanding of upper facial anatomy and its relationship to the aging process. As interest and research in this area continue to grow, improved quantification of surgical results becomes important.

Summary

There has been significant development and refinement of endoscopic approaches to foreheadplasty. Nonetheless, debate regarding the durability, quality of results, and complications of endoscopic versus open approaches continues. Ultimately, optimal results may be achieved through a variety of surgical techniques, but require a thorough understanding of the anatomic basis of aging, attention to detail, and adequate brow fixation.

Keywords

endoscopy, eyebrow lift, facial rejuvenation, fixation, forehead lift, foreheadplasty

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Introduction

Since the introduction of endoscopic techniques for surgical forehead rejuvenation 20 years ago [1], the ideal approach to management of the aging forehead has developed into an area of contentious debate among facial plastic surgeons. The initial enthusiasm over minimally invasive techniques appeared to wane as concerns over their significant learning curve and doubts about long-term durability of results began to surface [2,3]. In response, advocates of the endoscopic approach developed a wide array of brow-fixation methods. New insights into the understanding of upper facial anatomy and the factors contributing to the aesthetic changes seen in aging have also influenced the techniques used to rejuvenate the upper face [4••].

In this article, we review the latest developments in the surgical rejuvenation of the upper face – commonly known as forehead lift, brow lift, or foreheadplasty. We will focus on covering developments published in the literature in the previous 18 months. Particular attention is paid to recent innovations in endoscopic techniques, which range from surgical approaches and planes of dissection to methods for eyebrow fixation.

Open versus endoscopic: which is better?

‘Minimally invasive’ approaches to foreheadplasty gained increasing attention in the early 1990s following introduction by Keller *et al.* [1] of a small-incision technique utilizing a potassium titanyl phosphate (KTP) laser to create a subcutaneous dissection plane in the forehead. The prospective benefits of an endoscopic approach were immediately recognized as previous ‘open’ methods were known to suffer from the consequences of a large transverse scalp incision with resultant wound closure under tension, namely the potential for visible scarring, postoperative pain, forehead dysesthesia, and alopecia [3]. Endoscopic techniques continued to gather momentum with initial studies showing comparable short-term durability and fewer postoperative complications than open methods [5]. However, as early as 2001, surveys of plastic surgeons were published suggesting that initial enthusiasm for the endoscopic technique was beginning to wane, with some surgeons expressing concern over the actual effectiveness and long-term durability of endoscopic procedures [2,3].

In a recent study, Cilento and Johnson [6••] presented a compelling case for the renewed interest in open forehead rejuvenation. The authors performed a retrospective

chart review of 1004 open procedures performed by one surgeon from 1993 to 2005. Data regarding patient demographics, type of procedure (coronal versus trichophytic), complications, and need for revision were examined, with an average follow-up of 5 years. Their results showed an overall low rate of complications: need for revision, 0.57%; alopecia, 0.7%; persistent dysesthesia, 1.2%; ocular irritation, 7.37%; unsatisfactory scar, 0.2%. A questionnaire was also sent to all patients with current contact information, with an overall adjusted response rate of 416/650 (64%). Over 92% of respondents found the results of their scar to be 'excellent', 1% reported persistent alopecia, and over 99% were overall satisfied with their outcome. These results are noted to be comparable to or better than previously published complication rates and satisfaction indices for endoscopic surgery [2,3].

The authors partially attributed their high success rate in open foreheadplasty to attention to detail when performing the scalp incision. In particular, they emphasized the importance of appropriately beveling the incision to minimize the transection of adjacent hair follicles, gentle handling of tissue, and meticulous closure. These results should remind both surgeon and patient that coronal and trichophytic foreheadplasty still have an important place in the field of forehead rejuvenation, and may still be the preferred approach in select patients.

Brow fixation in endoscopic foreheadplasty

Concern over long-term durability of endoscopic forehead procedures has led to interest in developing improved methods for eyebrow fixation. There are numerous techniques by which brow fixation can be achieved, and controversy exists regarding the optimal method and durability of fixation. As most endoscopic methods require re-adhesion of a subperiosteal flap to bone, one initial speculation about failure of brow lift over time was that temporary fixation techniques were not allowing full periosteal re-adhesion. Romo *et al.* [7] showed in a rabbit model that significant periosteal-to-bone contact did not occur until 45 days postoperatively, and that histologic characteristics of the periosteum–bone junction did not resemble those seen in control animals until 12 weeks postoperatively. However, biomechanical studies using a similar rabbit model suggested that periosteal re-adhesion approaches preoperative strength within 2 weeks [8]. These conflicting findings carry over into clinical practice, when some surgeons find temporary fixation methods acceptable and others do not.

Keller and Mashkevich [9**] describe both permanent and temporary brow-fixation methods. If adequate release of the brow is achieved and the brow can be elevated without tension, the author performs permanent suture fixation from the temporoparietal fascia to the

superficial layer of deep temporal fascia with a figure-of-eight interlocking suture.

In patients for whom this tension-free elevation cannot be achieved, however, the author employs a creative temporary fixation method using transcutaneous screws. A predetermined distance for brow elevation is selected based on preoperative measurements. A short vertical temporal incision is made to bone, and a cortical screw is secured the premeasured distance behind the anterior apex of the incision. The skin is pulled posteriorly with a skin hook by the desired amount, and the incision is stapled closed behind the screw. The anterior-most staple abuts the screw and keeps the skin retracted. Staples are removed on postoperative week 2. The author reports no failure of fixation with this method to date.

Plastic surgeons have found many uses for braided sutures in facial surgery. A recent study by Badin *et al.* [10*] reviewed results of lateral brow fixation using braided sutures in a minimally invasive endoscopic forehead lift. The authors described a fixation technique that uses two points in the lateral eyebrow: one in the distal extremity of the brow and another corresponding to the midpoint between the pupil and the lateral canthus of the eye. Proximal fixation was to the deep temporal fascia using transcutaneous nylon-braided sutures through the lateral brow. Their results show a significant near and long-term durability with this type of pull.

Although the surgical technique was not new, the evaluation of the amount of pull sheds light on the efficacy of this type of surgery. Braided sutures have the advantage of having barbs which participate in force-sharing to potentially allow a greater overall pull as well as decrease the amount of skin dimpling/puckering at the point of end-fixation.

Another recent development has been with a modified use of Endotine materials. The Endotine Forehead (Coapt Systems, Inc., Palo Alto, CA) device is an effective bio-absorbable fixation tool for forehead and brow-lift procedures. However, the Forehead system has been found to be less effective for elevating the lateral brow [11]. To overcome this, Pascali *et al.* [12*] use a combination of the Forehead system medially and the Endotine Ribbon system laterally to achieve satisfactory pull. One standard Endotine Ribbon is cut in half and secured in the temporalis fascia, usually at 45 degrees. The brow is then pulled and maneuvered into the desired position before digitally securing it. By shortening the Ribbon system and using it to lift the temporal soft tissues, lateral brow lift is achieved. The results of the study show improved position of the lateral brow compared with using the Endotine Forehead system alone. The study showed the technique to also be well tolerated and time-effective.

Another variation on a classic endoscopic fixation technique is described by Malata and Abood [13^{*}]. The authors use a 'bevel-and-slide' modification of McKinney *et al.*'s [14] original description of paramedian cortical tunnel fixation. By creating a 'beveled' edge on cortical tunnel entrance and exit holes, the suture and needle are able to 'slide' more easily through, and the knot of the fixation suture can be buried within the tunnel. This modification addresses two difficulties previously described with the classic technique – advancement of the fixation needle through the cortical tunnel hole and knot-related complications of the fixation suture.

Keller and Mashkevich's [9^{**}] utilization of different fixation techniques depending on the clinical setting supports the notion that, to date, no single 'one-size-fits-all' method of fixation has emerged. Whereas many surgeons who perform endoscopic foreheadplasty tend to prefer a single fixation technique with which they have achieved consistent results and are most experienced, it is certainly worthwhile to be familiar with the multitude of other techniques available, and to recognize scenarios in which alternate fixation methods may be appropriate.

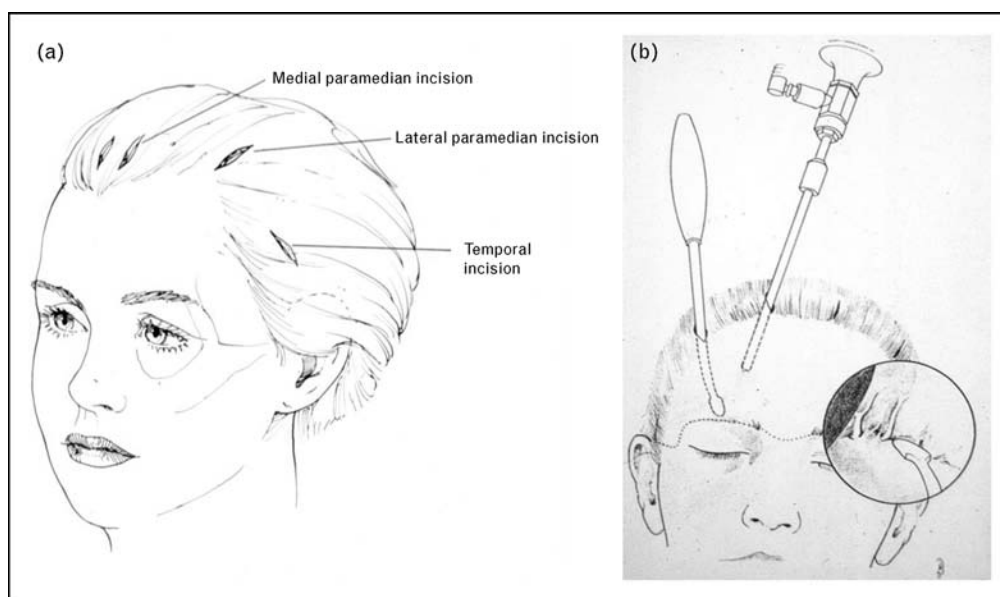
With this in mind, the senior author (T.R. 3rd) prefers a permanent method of fixation, with multiple brow-fixation points. Incisions, subperiosteal elevation, and myotomies are performed as previously described [15] (Fig. 1). The medial and central brow are fixed by placing a 2 mm diameter (3.5 mm length) titanium anchor in each

of the four medial and lateral paramedian holes. Each screw is fitted with a 2–0 or 3–0 Ethibond (Ethicon) suture, and the needle is passed through the periosteal–galeal soft tissue at the anterior extent of each incision and brought out of the incision. The sutures are then tied down under direct vision, pulling the anterior incision over the titanium anchor (Fig. 2). This method provides exact elevation and fixation of tissue at the desired brow height. The lateral brow is elevated by selecting a third fixation point superior and posterior to the inferior edge of the temporal incisions. Two 2–0 polygalactin sutures are then placed in the deep temporal fascia and passed through the dermis and superficial temporal fascia of the edge of the inferior temporal flap. The inferior temporal flap is manually advanced and the two polygalactin sutures are tied down and secured, thus elevating the lateral brow. The combination of permanent fixation sutures and multiple points of fixation provides durable, controlled, and accurate brow elevation (Fig. 3). This method has provided the senior author (T.R. 3rd) with consistently excellent results. Additionally, there is no need for a return visit for screw removal, and any question of whether or not adequate periosteal readhesion has occurred is rendered unimportant.

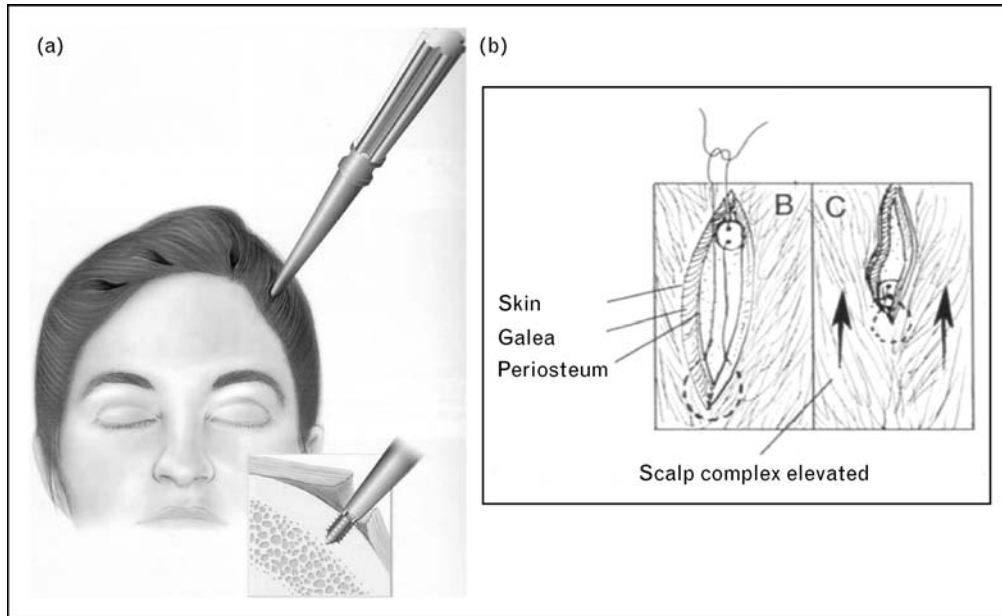
Brow position analysis

As research into better methods of eyebrow elevation and fixation grows, the ability to accurately quantify aesthetic changes in the upper face becomes a necessary research

Figure 1 Endoscopic forehead lift. Senior author's placement of scalp incisions and extent of subperiosteal dissection



(a) Six incisions are marked: one pair 2 cm lateral to the midline, the second pair centered on the lateral canthus, and the third approximately 2 cm behind and parallel to the temporal hairline. Incisions can be modified for patients with significant male-pattern baldness. (b) Lateral-to-medial subperiosteal dissection and release to the supraorbital rim is performed. The supraorbital and supratrochlear neurovascular bundles are identified and preserved. Adapted and modified from [16,17].

Figure 2 Senior author's technique: fixation and elevation of the forehead

(a) Schematic of screw placement. (b) The screw is placed at the premeasured distance behind the anterior vertex of the incision, and the scalp is lifted and fixed by the desired amount. Adapted and modified from [16,17].

tool for surgeons. Reliance on comparison of preoperative and postoperative photographs, as often occurs in retrospective studies, introduces potential inaccuracies in comparative measurements of facial features, that is, due to differences in preoperative brow ptosis as well as patient distance from the camera. Several studies in the current review period present creative methods for quantification of results in forehead rejuvenation.

Badin *et al.* [10^{*}] utilized the Mirror 6.0 (Canfield Imaging Systems, NJ, USA) digital imaging program to quantify brow elevation in a retrospective case series of 44 patients undergoing endoscopic foreheadplasty. Preoperative, postoperative (1–1.5 years), and late postoperative (3+ years) results were compared. A fixed anatomical measurement – the interpupillary distance – was used by the software program to standardize photographs for each patient. Then, through a line perpendicular to the interpupillary line, the distance between the eyebrow and the lateral canthus, the midpoint between the lateral canthus and the pupil, and the papillary midpoint were measured. All patients experienced persistent elevation of the lateral brow through the study period, although three patients had some fall in the medial measurement of the brow.

In a prospective study of 72 patients undergoing endoscopic foreheadplasty, Graf *et al.* [18] also utilized the Mirror program to demonstrate persistent eyebrow elevation at different postoperative intervals. A similar

method to that described by Badin *et al.* was used to measure medial and lateral brow elevation. However, photographs were instead standardized by calibrating the diameter of the right iris in each eye to 10 mm. An advantage of the approach used by Graf *et al.* is that measurements could be compared not only in preoperative and postoperative photographs, but also in photographs between all patients in the study.

Kim *et al.* [19^{**}] describe another approach: the 'brow elevation ratio'. In a retrospective review of 16 consecutive patients undergoing endoscopic foreheadplasty, preoperative and postoperative brow elevation were compared using the ratio between the vertical distance between the lateral corneal limbus and the superior brow and the horizontal distance between the lateral limbus and the medial canthus. The average follow-up was 18 months. The authors demonstrate an overall mean increase in brow position of 17.1%, with a persistence of this elevation in patients who were followed for more than 2 years. This intuitive measurement allows accurate cross-patient comparison of results using 'simple office photography' and eliminates the need for sophisticated computer programs.

Understanding aesthetic changes in aging

The concepts of ideal brow shape are constantly changing, and are also influenced by societal trends and cultural norms. Despite studies that provide criteria for

Figure 3 Preoperative and postoperative photographs. Both patients underwent foreheadplasty by the senior author

(a, b) Preoperative. (c, d) Postoperative, approximately 1 year later (original figures).

ideal brow aesthetics, studies in the literature suggest a disparity between the ideal and actual practice in brow-lift surgery. Matros *et al.* [4••] suggest that this may be due to a fundamental misunderstanding about the age-related changes in the upper one-third of the face. In a cross-sectional study of 70 patients, the authors compared eyebrow position in a 20–30-year-old group of women with that in a 50–60-year-old group. Most descriptions of age-related changes of the brow and forehead point to lateral brow ptosis as one main indicator of aging. However, in this study population, lateral brow position remained relatively unchanged between the young and mature groups, whereas medial and middle brow positions were actually higher in the mature group. Whereas this study is too small to draw conclusions about larger populations of patients, it nonetheless helps to understand why surgical elevation of the medial brow may provide results that are neither youthful nor aesthetically pleasing, and challenges traditional understanding of aging of the upper face. Given the results of this study, it is not surprising that as experience with endoscopic

techniques has grown, surgeons have begun to favor more lateral fixation points on the forehead. This allows isolated lateral brow elevation without raising the medial brow.

Conclusion

New concepts and methods continue to emerge in the management of the aging forehead. Although questions still remain about the durability of endoscopic approaches compared with the traditional open methods, continued modifications and improvements in endoscopic techniques hold great promise for this technique. New findings in age-related changes of the upper face are also still emerging, and will continue to refine the approach to forehead and brow-lift surgery. Ultimately, there is little doubt that consistent and durable results depend on an understanding of the aesthetic goals at hand, the selection of the appropriate procedure which can best meet those goals, and the individual surgeon's skill and experience with the technique being offered.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 345).

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- 2 Elkwood A, Matarasso A, Rankin M, *et al.* National Plastic Surgery Survey: brow lifting techniques and complications. *Plast Reconstr Surg* 2001; 108:2143–2150.
- 3 Chiu ES, Baker DC. Endoscopic brow lift: a retrospective review of 628 consecutive cases over 5 years. *Plast Reconstr Surg* 2003; 112:628–633.
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This large retrospective study compares the senior author's complication rates for open (coronal and trichophytic) forehead lifts versus currently published complication rates for endoscopic forehead lifts. Patient questionnaires were also gathered to illustrate high rates of long-term patient satisfaction with open techniques. A local survey was also performed to examine the importance of description bias in influencing patient perception of the available foreheadplasty techniques.
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Analysis of authors' experience with a previously described barbed suture fixation method. Utilization of the interpupillary distance to standardize preoperative and postoperative brow measurements.
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To prevent suture knot-associated complications previously described with the classic paramedian cortical tunnel fixation technique, the authors introduce a simple technical modification which facilitates passage of the fixation suture needle and prevents exposure of suture ends.
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- 18 Graf RM, Tolazzi AR, Mansur AE, Teixeira V. Endoscopic periosteal brow lift: evaluation and follow-up of eyebrow height. *Plast Reconstr Surg* 2008; 121:609–616.
- 19 Kim BP, Goode RL, Newman JP, *et al.* Brow elevation ratio: a new method of •• brow analysis. *Arch Facial Plast Surg* 2009; 11:34–39.
The authors describe a method for quantifying postoperative brow elevation using the ratio between the vertical distance between the lateral corneal limbus and the superior brow and the horizontal distance between the lateral limbus and the medial canthus. This simple method circumvents the need to account for variations in patient-to-camera distance and allows comparison of brow elevation across different patient groups.