Purpose of review
The purpose of this review is to provide the latest findings in the constantly changing field of brow and forehead lifting. Significant articles published in the last 24 months are reviewed and discussed based on the personal experience of the senior author (F.P.).

Recent findings
Important anatomical findings have been made over the last few years which will have an impact on plastic surgery of the upper third of the face, with new ligamentous structures of the forehead and more precise landmarks of the supraorbital neurovascular bundle being described. The short-term efficacy of a new device for periosteal fixation has been evaluated and new data have been collated about the time required for forehead periosteal readhesion.

Summary
In the last few years there have been important anatomical findings which will allow the development of more detailed and safe techniques for forehead lift surgery. New absorbable materials are available that allow efficient mechanical fixation of the soft tissues. The senior author of this review has extensive personal experience involving more than 400 cases. In addition to commenting on recent articles, we detail the methods we have used over the last 8 years, especially regarding the fixation technique.

Keywords
endoscopy, eyebrow, facial rejuvenation, forehead, lifting

Introduction
The early 1990s saw significant advances in aesthetic surgery of the upper third of the face, with the introduction of endoscopic treatment for forehead wrinkles, brow ptosis and asymmetry. Anatomical knowledge of this region had to be adapted according to the viewpoint of the endoscopic surgeon. The major advantage of the new endoscopic approach compared with the old coronal approach is a short incision resulting in less scarring and alopecia, and the avoidance of having to cut branches of the supraorbital nerve and thus long-term pruritus and hypesthesia. This approach also allows a more detailed view of the anatomical structures, resulting in a more conservative dissection of the neurovascular bundle and thus a lower rate of complications and long-term morbidity, making this procedure more attractive for the patients. Interest in the coronal technique seems to have diminished, with no articles on coronal brow and forehead lifting being found within the review period.

Landmark for the supraorbital nerve
A major consideration in endoscopic forehead and brow lifting is preservation of the supraorbital neurovascular bundle. The supraorbital and supratrochlear nerves are responsible for the innervation of the forehead and scalp; lesion of these nerves may lead to permanent paresthesia of the innervated area. A reliable anatomical landmark for the supraorbital nerve would be of special interest. In an in-vivo anatomical study, Cuzalina and Holmes [1] tried to determine the anatomical relation between the medial margin of the iris and the neurovascular bundle at the supraorbital rim. In addition, measurements were taken from the course of the supraorbital nerve to the course of the supratrochlear nerve. These authors evaluated 75 white patients (73 women), and a total of 150 sides were studied. A line was traced over the eyebrow parallel to the medial margin of the iris when the patients were awake and looking forward. A 27-gauge needle was placed over the line and the relation of the needle with the deep (lateral) branch of the supraorbital nerve was established with the aid of endoscope equipment. The authors found that the distance of the medial margin of the iris from the deep branch of the nerve was on average 0.56 mm (±0.7 mm). In 84 sides the needle was over the nerve; in 48 sides the needle was less than 1 mm from the nerve. In no case was the nerve course in the supraorbital rim greater than 3 mm from the landmark. The supratrochlear nerve was found to be 9.0 mm (±1 mm) medial from the deep branch of the supraorbital nerve.
The surgical routine of the senior author (F.P.) involves palpating and marking the supraorbital foramen before the procedure. This precise landmark helps to free the periosteal from the supraorbital rim without damaging the nerves and the vessels. Troublesome bleeding and paresthesia can be avoided when careful dissection of this area is performed. The periosteum is released over the supraorbital rim but aggressive uncapping of the periosteal sheet that involves the neurovascular bundle is avoided. In the supraorbital bundle, the periosteum is released with a blunt dissector, avoiding dissection of the neurovascular structures and the corrugator muscle in this area. A major consideration is to know the position of the neurovascular structure in order to preserve it. Dissection of this structure would increase the risk of injury and we see no benefit in cutting the corrugator in the ‘paquet’ area as we feel that some movement of the corrugator is desirable to preserve facial expression in the glabellar area. It is also important to preserve the supraorbital and supratrochlear nerves not only at the supraorbital level but also in the scalp. This is the reason why three of the five medial incisions that we make during a forehead lift are in a sagittal plane that runs parallel to the sensorial nerve branches of the scalp, thus reducing the risk of lesion of these branches (Fig. 1).

Figure 1 Incisions placed parallel to the branches of the supraorbital nerve

Retaining ligamentous structures of the forehead

In an interesting article [2**], Sullivan et al. describe the presence of three retaining ligamentous structures in the forehead and confirm the presence of a fourth retaining structure over the lateral portion of the supraorbital rim. This study was based on previous findings relating to other retaining ligaments of the face – the orbital ligament described by Knize and detailed by Moss et al. [3].

Dissection of six cadavers (eight facial halves) was performed in multiple planes: subperiosteal, subgaleal and subcutaneous. The described ligamentous structures were found to exit the frontal bone and attach to the frontalis muscle. The clinical importance of these structures according to Sullivan and colleagues [2**] is avoidance of the elevation of the medial brow, thus preventing the ‘surprised look’. They found that it was possible to improve the corrugator and procerus muscles without releasing these ligamentous structures from the periosteum.

Sullivan et al. [2**] use the subgaleal approach in brow lifting. We believe that if the subperiosteal approach is used, maintenance of the medial retaining ligamentous structures would not be possible, and dissection of the medial muscles (corrugator, procerus, depressor supercilis) would become very difficult to accomplish.

The advantages of preserving these ligamentous structures must be clinically evaluated. In our personal experience the shape of the brow can be adjusted after the release of the periosteum of the arcus marginalis and the treatment of the depressor muscles of the forehead. We have been using an adjuvant technique to the endoscopic subperiosteal forehead lift that enables the lateral and the medial brow to be treated as independent components. A stitch that passes through the periosteum and subcutaneous tissue of the eyebrow tail promotes the elevation of this specific site without changing the medial brow position (Figs 2 and 3).

Periosteal readhesion to the skull

Periosteum adhesion to the skull is fundamental in maintaining the desired results in subperiosteal forehead and brow lifts. Periosteal readhesion after surgical elevation was found to approach preoperative strength by the 12th postoperative day in a prospective animal model [4]. After that period, the periosteum–bone interface of the operated specimens was able to withstand the same amount of tensile shear force as the untouched specimens before separation of the periosteum from the skull. This study is a great contribution to the field with important practical implications. A previous study [5] suggested that a period of at least 6 weeks was necessary
for periosteum–bone adhesion, but this anterior study assessed only histological features of the healing process and no measurements were made of the tensile forces between the periosteum–bone interface. This new finding supports our clinical practice: we place a micropore shield over the forehead skin and support it in a higher position until the 9th or 10th day. After that, a small strip of micropore is placed laterally on the forehead and changed every 3 days for 2 weeks (Fig. 4).

New endoscopic device
The use of compact equipment for frontoplasty that is connected to a regular laptop by a USB port has been evaluated [6]. These authors emphasized that the equipment is easier and more compact than the traditional approach and thus allowed the surgical time to be reduced by 50%. This kind of innovation could be of special interest for surgeons in developing countries where costs are important limiting factors.

Evaluation of Endotine: absorbable fixation device
At the end of 2003, the US Food and Drug Administration approved the use of the Endotine (Coapt System, Inc., Palo Alto, California), a bioabsorbable copolymer fixation device for forehead and brow lifts. The efficiency of this device is evaluated in the article by Berkowitz et al. [7⁺].

The Endotine is composed of a post, a platform and a series of five tines projecting from the platform. The post is inserted into a small hole (4.25 mm) in the outer table of the cranium and the device is seated firmly against bone (subperiosteal). The authors studied 21 patients with an average follow-up period of 102 days (54–174 days). No adverse effects or complications were reported. Three measurements were taken before and after surgery: the distance between the mid pupil and the brow; the distance between the mid pupil and the hairline; and the distance between the lateral canthus and the lateral brow. In all three measurements there was an average increase of around 4 mm ($P < 0.000$). The advantages reported included the time required for fixation – between 60 and 90 s for each device – reliable fixation, and reduced tension in the periosteum fixation owing to the multiple tines that distributed the tensile forces.

When studied in vitro the Endotine was found to absorb slowly over 12 months.
As previously stated, the senior author uses a nonabsorbable suture and distributes the tensile force over several points from periosteum to periosteum in the frontal area and in the temporal area from the superficial temporal fascia to the deep temporal fascia (Fig. 2b). The major difference in this technique is the distribution of the tensile force into several vectors that, in our opinion, probably provides a more versatile approach and better aesthetic results. The ideal method of brow fixation would allow the lateral and medial components of the brow to be addressed individually, effectively holding the brow position until healing has occurred, as well as being reproducible, minimizing complications, requiring minimal training and equipment, and being cost-effective [8].

### Pretrichial endoscopic brow lift for patients with previous coronal brow lift

The success of endoscopic brow lifting in the primary approach to brow ptosis suggests that it would be an excellent choice for any secondary lift. Based on that premise, the effectiveness and the safety of the endoscopy forehead lift was evaluated in patients who had previously undergone a coronal brow lift [9]. The authors evaluated 63 cases of secondary endoscopic brow lifts. They used two different techniques, both with pretrichial incisions: 49 patients underwent what they call a minimal incision endoscopic technique and the other 14 patients underwent a biplanar endoscopic technique. The minimal incision endoscopic technique described in the article uses three small triangular pretrichial incisions to gain soft-tissue access to the subperiosteal dissection to develop an optic cavity between the hairline and the supraorbital rim. In the biplanar approach a pretrichial incision is made between the temporal regions and the subcutaneous plane is bluntly dissected 3 cm anterior to the hairline. Then, three vertical incisions are made in the frontalis muscle to enter the subperiosteal plane and allow the endoscopic resection of depressor muscles. A 1–1.5 cm plicature of the frontalis muscle is also made and the excess skin tailored before suturing.

The authors concluded that the endoscopic approach offered safety in patients who had undergone a prior elevation of the brow by coronal forehead lifting without displacement of the anterior hairline and other complications.

A 97% rate of patient satisfaction was reported. The average follow-up was 21 months (range 1–7 years). Six complications were reported (one case of forehead dysesthesia, one forehead irregularity, one eyebrow malposition, one persistence of horizontal forehead wrinkles and two hematomas). The authors stated that the type and rate of complications were similar to those of primary

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**Figure 3 Pre and postoperative photographs**

(3.1–3.4a) Preoperative photographs. (3.1–3.4b) Postoperative photographs, 1 year after the frontoplasty technique, carried out by the senior author. Observe the better postoperative position of the lateral eyebrow without significant change of the medial eyebrow position.
brow lifting. Although it was reported that the results were long lasting, pre and postoperative measurements of the brow elevation were not undertaken.

Based on our personal experience, we agree with the findings that the index of complications of secondary brow lifting performed on patients who have undergone previous coronal forehead lifting is similar to the primary surgery, as are the results. We feel, however, that although the pretrichial incision is helpful in avoiding a rise in the hairline, it is no longer justifiable as a primary choice even in secondary brow lift patients. The elevation of the hairline with a coronal forehead lift is about 2 cm; this also occurs when posttrichial forehead lift endoscopic surgery is performed, but this elevation is no greater than the amount elevated in the brow – around 2 mm. This, in our opinion, is more acceptable than the risk of a possible unaesthetic scar.

**Endoscopic pretrichial brow lift**

Tower and Dailey [10] present an alternative technique for rejuvenating the upper face of patients with high hairlines with the endoscopic approach while excising skin, avoiding further recession of a high hairline. This study is a retrospective analysis of 22 cases in which the authors reviewed endoscope-assisted pretrichial brow lifts over a 4-year period.

The authors describe in detail their specific surgical technique. The pretrichial incision is made with either a CO2 laser or a scalpel, down to the superficial galea. Approximately 15 mm of skin and subcutaneous tissue are elevated inferior to the incision, exposing the frontalis muscle. Laterally the dissection is carried through the temporoparietal fascia to the deep temporalis fascia.

The usual endoscopic ports are made in the central and paracentral dissection bed, deep in the skin flap through the frontalis muscle, galea and periosteum. The pocket is then created subperiosteally through the central and paracentral incision.

Bitemporal dissection is performed. Using the endoscope, the conjoint fascia is released from its insertion in the temporal line, and the procerus and the corrugators are stripped to achieve the desired elevation in a graded fashion. Fixation is made with galeal/frontalis plication with 3-0 monocryl sutures.

The patients were rated by an objective evaluator to ascertain position, smoothness, symmetry and satisfaction. The dissection over the frontalis muscle using this approach allows the removal of excess skin and redraping of the smooth skin over the frontalis muscle.

One of the great advantages of the endoscopic approach is the small incisions on the scalp. This advantage is lost using this technique. The authors showed an index of satisfaction on a subjective basis. No measurements were taken of the brow elevation. Another important bias is that no evaluation of the resultant scar was made and the patients were not asked specifically about their satisfaction with the scar.

**Transpalpebral brow lift**

Niechajev [11] reviews classic techniques and transpalpebral browpexy and proposes an alternative method for eyebrow suspension through transpalpebral incision. He describes in detail the surgical technique used for transcutaneous internal muscle plication.

The fixation points are marked on the surface of the frontalis muscle, medially 5 mm, centrally 8 mm and laterally 10 mm above the orbital arch. Nonresorbable soft, multibraided 3-0 suture on a cutting needle with a circle diameter of 22 mm is used for fixation. The needle is first introduced transcutaneously, at the lower border of the eyebrow. It pierces the flap and comes out on the undersurface of the orbicular muscle, indicating the proper level for the internal suture. The anchoring stitch is made at the
marked point through the frontalis muscle and the level of the piercing thread, through the undersurface of the orbicular muscle and is pulled inside the pocket. The medial and lateral sutures are left untied and threads are secured with the small clamp. Then, all three knots can be tied, starting from the lateral one.

The palpebral incision is left open and the side symmetry is assessed. Lid skin is closed with intracutaneous 5-0 monofilament nylon.

Forty-three patients were followed, 38 of them for more than 4 years. The elevation effect gradually decreased but persisted, with wide variations between 1.5 and 7 more years. At the last follow-up examination 36 of 43 patients had maintained lateral brows in position at least at the level of the orbital margin, the same position as before surgery.

The author recommends this technique as a minimally invasive method for correcting minor asymmetries after endoscopic or coronal brow lift, and indications included patients with lateral brow ptosis, discrete forehead wrinkles and bald men. The results are very interesting and one important observation was that the younger patients had longer-lasting results.

Conclusion
In the recent literature it is evident that researchers are concerned with the mechanism of fixation of the soft tissue of the brow and forehead (the ligamentous structures, time required for periosteal readhesion and the Endotine system). Reliable fixation seems to be vital in obtaining a successful outcome in brow and frontoplasty. It is possible that the comprehension of the role of ligamentous structures in the support of the soft tissue of the forehead would help us to better understand the aging process of the upper third of the face and to develop new concepts for the surgical management of this area.

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. 292).

In-vivo study of the anatomical relation of the medial limbus of the iris with the supraorbital nerve. The relation of the supratrochlear nerve with the supraorbital nerve is also assessed. The anatomy of the supraorbital nerve is briefly reviewed.

This anatomical study describes three ligamentous structures in the forehead. The authors tried to associate the release of these ligamentous structures and an unaesthetic surgical outcome resulting from elevation of the medial brow: the ‘surprised look’.


Prospective study with 21 patients that assesses the elevation of the eyebrow provided by Endotine (an absorbable fixation device) in the short term.


In this article, the authors show a retrospective review of 63 patients with previous coronal brow lifts that underwent an endoscopic forehead lift. Two different pretrichial techniques were used. The results and safety of secondary surgery were evaluated.
