Comparison of Subperiosteal vs Subgaleal Elevation Techniques Used in Forehead Lifts

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**Objectives:** To compare eyebrow and forehead elevation and tension among the following 3 surgical techniques: subperiosteal dissection to the supraorbital rim, subperiosteal dissection with release (elevation, incision, and spread) of periosteum at the supraorbital rim, and subgaleal dissection to the supraorbital rim, and to determine the optimal method of elevation in an aesthetically accepted range for the endoscopic forehead lift.

**Design:** A randomized, self-controlled study using an open approach to the forehead in cadaver heads. Each half of head was compared with the other in the following 2 study groups: subperiosteal dissection without release vs subperiosteal dissection with release of periosteum (group 1) and subperiosteal dissection with release of periosteum vs subgaleal dissection.

**Setting:** Anatomy laboratory at a university medical center.

**Subjects:** Eight cadaver heads fixed with ethylene glycol in each group.

**Intervention:** Predissection distances in millimeters from fixed anatomic landmarks were measured. The forehead flaps were elevated using a coronal incision and divided with a midline incision for side-to-side comparison. Cadaver heads and side of surgical intervention were selected randomly. The flap tensions associated with incremental flap advancement of 0.5 and 1.0 cm were measured. Traction of 2.2 kg was then applied to each flap, and distances between the fixed landmarks were measured.

**Main Outcome Measures:** Mean predissection and postdissection distance of brow and forehead elevation for each dissection type and mean distance and median tension of brow and forehead elevation within each group.

**Results:** The mean postdissection brow measurements at rest were significantly greater than the mean predissection measurements at most landmarks in all dissections for both groups (P<.05). The mean postdissection brow and forehead measurements with 2.2 kg of traction were significantly greater than the mean predissection measurements at all landmarks in all dissections for both groups (P<.05). The mean increase in distance from predissection to postdissection (at rest and with 2.2 kg of traction) did not significantly differ between the different dissection types (P>.05). For group 1, the median flap tension for subperiosteal dissection without release was greater than that for subperiosteal dissection with release (P>.05). For group 2, subperiosteal dissection with release had greater median flap tension than subgaleal dissection (P>.05).

**Conclusions:** All 3 methods of dissection significantly elevated the brow at rest for most landmarks. All 3 methods of dissection significantly elevated the brow and forehead when traction was applied to the flap. Brow and forehead elevation at rest and with 2.2 kg of traction did not significantly differ between the dissections. Subgaleal dissection was associated with less flap tension compared with the subperiosteal dissection with or without release. The data support the use of all 3 methods of forehead dissection for brow elevation and subgaleal forehead dissection as the optimal approach for the forehead lift, whether performed endoscopically or open.

MATERIALS AND METHODS

SUBJECTS

Eight cadaver heads fixed with ethylene glycol were used in each study group, for a total of 16 heads (32 sides). Cadaver heads and side of surgical intervention were selected randomly. Each half of head was compared with the other as the control. Demographic characteristics are reported in Table 1.

METHODS

Cadaver dissections were performed in the anatomy laboratory at St Louis University School of Medicine, St Louis, Mo. The head was held in the supine position using a halo head holder (Figure 1). Immediately before the dissection, the orbital globes were injected with ethylene glycol fixative to reproduce normal orbital volume. Using a caliper, predissection distances in millimeters from fixed anatomic landmarks were marked, measured, and recorded on both sides of each head. These included measurements from the medial canthus (MC), midpupil (MP), and lateral canthus (LC) to the top of the eyebrow (EB) and from EB at the midpupillary line to the anterior hairline (AH). These fixed anatomic landmarks are used in aesthetic eyebrow and forehead analysis. To reduce measurement variability, one of us (P.S.N.) made all predissection and postdissection measurements.

Measurements used for the coronal incision were 10 cm superior to the nasion for the midline and 10 cm from the LC into the temporal scalp to a tangential line from the alar-facial groove to the LC. Coronal incisions were made with a number 10 blade, and a midline incision through skin to cranium from the nasion to the coronal incision made to divide the coronal flap. The lateral extent of the coronal flap was the superior helical crus. Incisions over the temporalis muscle were to the level of the deep temporalis fascia. Medial to the temporal crest, incisions were subperiosteal for subperiosteal flaps and subgaleal for subgaleal flaps.

Depending on the dissection type, the medial forehead was elevated in the subperiosteal or subgaleal plane to the supraorbital rim and nasion. Blunt temporal dissection was then performed over the deep layer of the deep temporalis fascia and below the temporal fat pad. The temporal dissection was joined to the forehead dissection by bluntly incising through the temporal crest. The inferior, inferomedial, and medial borders of the temporal dissection were the zygomatic arch, lateral orbital rim, and temporal crest, respectively.

The supraorbital and supratrochlear nerves were carefully dissected free from the surrounding muscle and soft tissue and preserved in all heads. corrugator supercilii, depressor supercilii, and procerus myotomies were performed on all 32 sides of heads (Figure 2). There were no modifications to the frontalis muscle. To access the muscles in the subperiosteal dissections without release, a 2.5-cm incision was made through the overlying periosteum in the medial brow region. Direct access to the muscles was obtained in the subgaleal and subperiosteal dissections with release.

In group 1, the forehead was elevated in a subperiosteal plane on both sides of the 8 heads. The periosteum was then released only on 1 side of these 8 heads from the Whitnall tubercle to the nasion. In group 2, subperiosteal dissection with release was performed on 1 side, whereas subgaleal dissection was performed on the other (Figure 3). The method of dissection was randomized with respect to sides within groups.

TENSION AND RETRACTION METHODS

A sharp towel clamp was applied to each forehead flap 1.5 cm anterior to the coronal incision in a vertical line from the LC. A digital force gauge (Chatillon, Greensboro, NC) was attached to the end of the towel clamp and used to measure kilograms of peak tension in the forehead flaps with incremental posterior flap advancement of 0.5 and 1.0 cm (Figure 4). The force gauge was calibrated before each measurement.

A pulley with a 2.2-kg weight was attached to the clamp, brief constant posterior traction was applied to the flap, and measurements were made and recorded (Figure 5). This weight simulated maximal brow elevation when significant retraction is applied to the flap in a forehead lift.

STATISTICAL ANALYSIS

Paired t tests were used to determine the statistical significance of mean brow and forehead elevation (ie, the average increase from predissection to postdissection) from the MC, MP, LC, and AH to EB. Two-tailed tests were used with a .05 level of significance. The purpose of this analysis was to estimate mean brow and forehead elevation associated with each dissection method at each of the 4 facial landmarks. The 95% confidence interval (CI) estimates of the mean elevation were computed.

Two-tailed paired t tests were used to compare mean brow and forehead elevations from predissection to postdissection (at rest and with 2.2 kg of traction) between both dissection methods in each study group. Elevation was computed as the absolute and relative increases in distance from predissection to postdissection. The Bonferroni method of adjustment for multiple comparisons was considered. However, even at the unadjusted level of significance (α = .025), none of the comparisons were statistically significant.

Median peak tensions of the forehead flaps with incremental posterior flap advancement of 0.5 and 1.0 cm were computed and compared between dissections. A tension greater than 4.5 kg could not be measured reliably, since this was the maximal capacity of the digital force gauge. Therefore, the tension measurements had to be truncated at 4.5 kg. In some cases, the flaps ripped at high tension. For this reason, the median rather than the mean was computed. The 1-tailed Wilcoxon test for comparing 2 related samples was used to compare tension and flap rip between dissection methods in each study group.
to determine the optimal method of dissection in an aesthetically accepted range. These included subperiosteal dissection of the forehead to the supraorbital rim, subperiosteal dissection with release of periosteum at the supraorbital rim, and subgaleal dissection of the forehead to the supraorbital rim. This investigation consisted of the following 2 study groups: subjects undergoing subperiosteal dissection without release vs subperiosteal dissection with release and those undergoing subperiosteal dissection with release vs subgaleal dissection.

#### RESULTS

**BROW AND FOREHEAD ELEVATION**

Table 2 summarizes the predissection and postdissection brow and forehead measurements of MC, MP, and LC to EB (top of eyebrow) and of EB to AH at the midpupillary line for both groups. In group 1, the mean
The pulley with a 2.2-kg weight attached to the forehead flap using Figure 5.

The mean postdissection measurements with 2.2 kg of traction for the subperiosteal dissection without release were significantly greater than the mean predissection measurements for MC ($P = .02$), MP ($P < .001$), and LC ($P = .03$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (0.17-1.62), MP (0.87-1.61), LC (0.13-1.56), and AH (−0.41-2.46). The mean postdissection measurements with 2.2 kg of traction for the subperiosteal dissection without release were significantly greater than the mean predissection measurements for MC ($P = .01$), MP ($P < .001$), and AH ($P = .008$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (0.71-3.77), MP (2.31-4.33), LC (1.43-5.25), and AH (0.88-4.20).

The mean postdissection measurements at rest for the subperiosteal dissection with release in group 1 were significantly greater than the mean predissection measurements for MC ($P = .01$), LC ($P = .02$), and AH ($P = .003$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (0.47-2.39), MP (−0.33-1.67), LC (0.28-1.96), and AH (0.31-1.01). The mean postdissection measurements with 2.2 kg of traction for the subperiosteal dissection with release were significantly greater than the mean predissection measurements for MC ($P = .02$), MP ($P = .003$), LC ($P = .001$), and AH ($P = .009$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (1.61-4.99), MP (1.83-5.87), LC (2.88-7.03), and AH (0.65-3.21).

In group 2, the mean postdissection measurements at rest for the subgaleal dissection were significantly greater than the mean predissection measurements for MC ($P < .001$), MP ($P = .02$), and LC ($P = .04$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (1.04-2.09), MP (0.30-2.21), LC (0.06-1.21), and AH (−0.25-3.21). The mean postdissection measurements with 2.2 kg of traction for the subgaleal dissection were significantly greater than the mean predissection measurements for MC ($P < .001$), MP ($P < .001$), LC ($P < .001$), and AH ($P < .001$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (3.68-5.57), MP (4.11-7.11), LC (4.36-6.98), and AH (1.38-7.15).

The mean postdissection measurements at rest for the subperiosteal dissection with release in group 2 were significantly greater than the mean predissection measurements for MC ($P = .03$) and LC ($P = .02$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (0.77-2.43), MP (−0.35-2.22), LC (0.33-2.40), and AH (−0.48-1.80). The mean postdissection measurements with 2.2 kg of traction for the subperiosteal dissection with release were significantly greater than the mean predissection measurements for MC ($P = .004$), MP ($P = .002$), LC ($P = .001$), and AH ($P = .002$) to EB. The 95% CIs for the mean differences at each landmark were as follows: MC (3.68-5.57), MP (2.89-8.32), LC (2.95-7.88), and AH (1.86-5.39).

In group 1, the mean increase in distance from predissection to postdissection (at rest and with 2.2 kg of traction) at the MC, MP, LC, and AH to EB landmarks did not differ significantly between the subperiosteal dissections without and with release ($P > .05$). In group 2, the mean increase in distance from predissection to postdissection (at rest and with 2.2 kg of traction) at the MC, MP, LC, and AH to EB landmarks did not differ significantly between the subperiosteal dissections with release.

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**Table 2. Brow and Forehead Elevation Measurements**

<table>
<thead>
<tr>
<th>Dissection Type*</th>
<th>Medial Canthus</th>
<th>Midpupil</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predissection</td>
<td>Postdissection</td>
</tr>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subperiosteal elevation with no release‡</td>
<td>27.8 (4.4)</td>
<td>28.7 (4.3)$§$</td>
</tr>
<tr>
<td>Subperiosteal elevation with release</td>
<td>28.7 (4.2)</td>
<td>30.1 (4.3)$§$</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subgaleal elevation</td>
<td>26.4 (1.5)</td>
<td>28.0 (1.7)$§$</td>
</tr>
<tr>
<td>Subperiosteal elevation with release</td>
<td>27.2 (2.2)</td>
<td>28.8 (2.1)$§$</td>
</tr>
</tbody>
</table>

*For a description of the groups, see the “Methods” subsection of the “Materials and Methods” section.
†Indicates measurement with 2.2 kg of retraction.
§No statistically significant differences were found between both dissection types at any measurement location in group 1.
‡No statistically significant differences were found between both dissection types at any measurement location in group 2.
§Statistically significant difference between mean predissection and postdissection or mean predissection and 2.2 kg (2-tailed t, $P < .05$).
||No statistically significant differences were found between both dissection types at any measurement location in group 2.
MP, LC, and AH to EB landmarks did not differ significantly between the subperiosteal dissection with release and the subgaleal dissection (P > .05).

**BROW AND FOREHEAD TENSION**

Table 3 summarizes the forehead flap tension results with advancement of 0.5 and 1.0 cm for each dissection type in both groups. In group 1, the median flap tension for advancement of 0.5 and 1.0 cm for the subperiosteal dissection without release was greater than that for the subperiosteal dissection with release, but this difference was not significant (P > .05). When advanced 1.0 cm, the tissue tore in 3 (38%) of the 8 subperiosteal dissections without release vs 1 (12%) of the 8 subperiosteal dissections with release (P > .05). When advanced 1.0 cm, the tension was greater than 4.5 kg for 6 (75%) of the 8 subperiosteal dissections without release vs 1 (12%) of the 8 subperiosteal dissections with release (P = .03). The 1 flap that tore in the group undergoing subperiosteal dissection with release had greater than 4.5 kg of tension when advanced 1.0 cm.

In group 2, the median flap tension for advancement of 0.5 and 1.0 cm for the subperiosteal dissection with release was greater than that for the subgaleal plane of dissection, but this difference was not significant (P > .05). When advanced 1.0 cm, the tissue tore in 2 (25%) of the 8 subperiosteal dissections with release vs 0 (0%) of the 8 subgaleal dissections (P > .05). When advanced 1.0 cm, the tension was greater than 4.5 kg in 2 (25%) of the 8 subperiosteal dissections with release vs 1 (12%) of the 8 subgaleal dissections (P > .05). The 2 flaps that tore in the group undergoing subperiosteal dissection with release had greater than 4.5 kg of tension when advanced 1.0 cm.

**COMMENT**

Many facial plastic surgeons now use the endoscopic forehead lift in lieu of the traditional coronal forehead lift for the treatment of brow ptosis. The primary reason for this transition is that the endoscopic approach allows brow elevation without an extended incision across the patient’s scalp as required in a coronal lift. Although long-term results of endoscopic forehead lifting are not available, many different techniques for this approach have been described.1-10 One of the earliest reports of the endoscopic approach described a subgaleal forehead dissection to the level of the supraorbital rim with subperiosteal dissection in the region of the supraorbital and supratrochlear nerves.3 Other endoscopic techniques described include subperiosteal forehead dissection,10 subperiosteal forehead dissection with release of the peristomeum at or above the arcus marginalis,4 subperiosteal dissection with release combined with subgaleal dissection in certain parts of the forehead,13 and combined subperiosteal and subcutaneous dissections.7 The term periosteal release has been used in the literature with varying definitions.6 Our study defined release as the elevation, incision, and spreading of the peristomeum from the lateral orbital rim of 1 orbit to the lateral orbital rim of the contralateral orbit immediately superior to the arcus marginalis.

The most common plane of dissection for the endoscopic forehead lift is subperiosteal.2,4,6 Proposed advantages of a subperiosteal dissection include the following: a better endoscopic optical cavity than the subgaleal or subcutaneous plane of dissection, the bony landmarks and fascial attachments that help the surgeon more easily with orientation, a safer and quicker procedure, maintenance of continuity if other endoscopic procedures are to be performed (ie, a midface lift), decreased bleeding, and excellent vascularity of the subperiosteal flap.2 Conversely, dissections in a subgaleal plane or in a combination of subgaleal and subperiosteal plane have certain benefits. Proposed advantages of subgaleal dissection include the following: reduced postoperative muscle movement,12 improved forehead skin support by allowing the pericranium to adhere to the cut edges of the galea,13 easier identification and direct resection of muscles,12 and the ability to elevate the medial brow separately rather than the entire brow as a unit.1

<table>
<thead>
<tr>
<th>Mean (SD), mm</th>
<th>Lateral Canthus</th>
<th>Anterior Hairline</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Predissection</td>
<td>Postdissection</td>
</tr>
<tr>
<td>Lateral Canthus</td>
<td>29.8 (2.9)</td>
<td>30.6 (2.6)§</td>
</tr>
<tr>
<td>29.7 (1.4)</td>
<td>30.8 (1.1)§</td>
<td>34.7 (3.3)§</td>
</tr>
<tr>
<td>26.2 (2.9)</td>
<td>26.9 (3.0)§</td>
<td>31.9 (3.2)§</td>
</tr>
<tr>
<td>25.8 (1.8)</td>
<td>27.1 (2.4)§</td>
<td>31.1 (3.6)§</td>
</tr>
</tbody>
</table>
A significant number of subperiosteal dissections without release needed more than 4.5 kg of tension for flap advancement of 1.0 cm compared with subperiosteal dissections with release (P = .03). The probable cause of this increase in tension is secondary to the undivided periosteal attachment at the arcus marginalis. In addition, we hypothesize that increased flap tension and the aging process may contribute to future loss of postoperative brow and forehead elevation. The data eliminated any age influences on flap tension, since skin tension decreases with age,\[^{14}\] by demonstrating no significant difference in age between the groups. Our study revealed less flap tension with the subgaleal dissection compared with the subperiosteal dissection with or without release.

Many proponents of the subperiosteal endoscopic technique claim that the limiting factor for eyebrow elevation is the periosteum, and that a release of the periosteum is most effective, then is a periosteal release indicated? We attempted to answer these questions.

Among the 3 dissection techniques, the data demonstrated significant postdissection brow elevation at rest in all of the fixed anatomic landmarks (\(P<.05\)), except for MP to EB in the subperiosteal elevation with release dissection. In group 1, significant postdissection forehead elevation at rest was achieved for subperiosteal dissection with release (\(P<.05\)). Postdissection brow and forehead elevation was achieved with 2.2 kg of traction applied to each flap for all dissections (\(P<.05\)). In group 1, no significant difference was obtained for postdissection brow and forehead elevation (at rest and with 2.2 kg of traction) between subperiosteal dissections without and with release (\(P>.05\)). In group 2, no significant difference was noted for postdissection brow and forehead elevation (at rest and with 2.2 kg of traction) between subgaleal dissection and subperiosteal dissection with release (\(P>.05\)). The data suggest that subgaleal dissection and subperiosteal dissection with and without release equally elevate the brow and forehead when traction is applied.

We do not accept the concept of tissue "creep" as an explanation for brow and forehead elevation when traction was applied to the flaps, since a moderate amount of time and repeated advancements are required for creep to occur.\[^{14}\] Creep refers to the increase in length of skin when placed under constant tension. We placed the flaps on traction once and for a brief period. One may question whether cadaver soft tissue can be compared with living soft tissue in this type of experiment. The cadaver heads were embalmed with ethylene glycol, which maintains the natural flexibility and suppleness of soft tissue. This is imperative for a study in cadavers when undermining and advancing of tissue are being used.

Some authors suggest that treatment (myectomies or myomotomies) of the brow depressor muscles is necessary for brow elevation.\[^{1-5,7-9}\] Others suggest that sufficient eyebrow elevation can be achieved without either treatment.\[^{8}\] To eliminate this variable, myotomies of the corrugator supercilii, depressor supercilii, and procerus muscles were performed on all specimens. To the best of our knowledge, no clinical data exist comparing brow elevation with or without brow musculature modification. Future studies on this subject are warranted.

Another technical aspect of the endoscopic forehead lift that varies considerably is the location of the periosteum incision. It has been released at the arcus marginalis, just superior to the arcus marginalis, or at different levels above the supraorbital rim.\[^{1,2,4,10}\] Dissection through the arcus marginalis may cause increased periorbital ecchymosis.\[^{1}\] Therefore, the periosteum was incised immediately superior to the arcus marginalis if a release was performed.

### Table 3. Forehead Flap Tension Results With Advancements of 0.5 and 1.0 cm

<table>
<thead>
<tr>
<th>Dissection Type*</th>
<th>Advancement, Median (Interquartile Range), kg</th>
<th>Comment†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subperiosteal elevation with no release</td>
<td>2.4 (1.7) 4.5 (1.0)‡</td>
<td>Comment: 3 (38%) tore; 6 (75%) had tension &gt;4.5 kg‡</td>
</tr>
<tr>
<td>Subperiosteal elevation with release</td>
<td>1.5 (1.4) 3.7 (1.1)</td>
<td>1 (12%) tore; 1 (12%) had tension &gt;4.5 kg‡</td>
</tr>
<tr>
<td>Group 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subgaleal elevation</td>
<td>1.2 (0.7) 2.8 (1.8)</td>
<td>0 (0%) tore; 1 (12%) had tension &gt;4.5 kg‡</td>
</tr>
<tr>
<td>Subperiosteal elevation with release</td>
<td>1.6 (1.8) 3.2 (1.6)</td>
<td>2 (25%) tore; 2 (25%) had tension &gt;4.5 kg‡</td>
</tr>
</tbody>
</table>

*For a description of the groups, see the “Methods” subsection of the “Materials and Methods” section.
†For advancement of 1.0 cm only.
‡P = .03.

**CONCLUSIONS**

We critically evaluated subperiosteal dissection of the forehead to the supraorbital rim, subperiosteal dissection with release of periosteum at the supraorbital rim, and subgaleal dissection of the forehead to the supraorbital rim. Eyebrow and forehead elevation and tension using both sides of the same forehead for comparing different dissection techniques were measured. We found the following: (1) All 3 methods of dissection significantly elevated the brow at rest except for the distance from MP to EB in the subperiosteal dissections with release. (2) All 3 methods of dissection significantly elevated the brow...
and forehead when traction was applied to the flap. (3) Brow and forehead elevation at rest and with 2.2 kg of traction did not significantly differ between the dissections. (4) Subgaleal dissection was associated with less flap tension compared with the subperiosteal dissection with or without release. These data support the use of all 3 methods of forehead dissection for brow elevation.

In endoscopic forehead lifts, a primary factor that needs to be considered is adequate visualization of anatomical structures. Although subperiosteal dissection provides better visualization compared with subgaleal dissection, most surgeons perform the upper two thirds of the forehead dissection without an endoscope. In addition, some evidence exists that removal of the central frown muscles subgaleally at their insertion rather than subperiosteally at their origin under endoscopic visualization reduces postoperative movement when compared with subperiosteal muscle resection. These factors may obviate the need for subperiosteal forehead dissection. Therefore, subgaleal forehead dissection appears to be the optimal approach for the forehead lift, whether performed endoscopically or open. A follow-up clinical study evaluating the subgaleal approach in the endoscopic forehead lift is planned.

Accepted for publication July 15, 1998.


We thank Barabara A. Macon for her assistance with the anatomical dissections and Bill Lefere, of Karl Storz Endoscopy–America, Inc (Culver City, Calif), for use of his instrumentation. We also gratefully acknowledge Chatillon, Greensboro, NC, for use of their digital force gauge and the Gift Body Program of the Department of Anatomy and Neurobiology, St Louis University School of Medicine, St Louis, Mo, for the cadavers.

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