Evaluation of Pericranial Skull Adherence During Healing in the Rabbit Model

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Background: The endoscopic brow-lift is a popular technique for rejuvenation of the aging brow and forehead. Long-lasting results depend on readherence of the pericranium to the underlying skull in the newly elevated position. Determination of the time required for pericranial reattachment to occur is important when considering optimal brow fixation time postoperatively; however, few studies of pericranial healing exist in the literature.

Objective: To quantify the time required for pericranial adherence after pericranial elevation in a rabbit model.

Design: Anesthetized New Zealand white rabbits underwent elevation of a pericranial flap on day 0. The flap was then repositioned and the skin sutured. One unoperated-on group served as a control. A tensiometer was used to measure the force required to separate the pericranial flap from the skull of the control animals and of test animals killed on postoperative days 3, 5, 8, 10, 13, 17, 20, 25, and 28. Statistical analysis was performed to determine the effect of healing time on the strength of pericranial adherence.

Results: There was a statistically significant decrease in the force required for pericranial separation at 3 and 5 days after surgery compared with the control group. By 8 days postoperatively and throughout the subsequent times examined, no statistically significant differences from the control group were observed.

Conclusion: In this rabbit model, pericranial adherence (as measured by tensile strength) is decreased postoperatively and does not return to baseline levels until postoperative day 8.

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The facial plastic surgeon has many techniques available for rejuvenation of the aging brow and forehead. Considerations such as hairline, skin texture, degree of brow ptosis, glabellar furrows, and brow asymmetry influence the surgical approach used.

Traditionally, browplasty approaches include the gold standard coronal incision and its variants. This technique offers excellent exposure and hides the scar within the hairline. This approach is not without its drawbacks, however. Alopecia, poor scar healing, and hypesthesia are potential complications.

Modifications of the coronal incision include the pretrichial and trichophytic incisions. These do not alter the hairline height, but may create a visible scar. The midforehead approach creates a central incision in an existing forehead crease. It is carried out in a subcutaneous plane and offers precise brow elevation with less sensory disturbance than other incisional techniques but has the potential for a suboptimal forehead scar. The direct brow approach relies on selective excision of skin directly above the eyebrows and suspension of the orbicularis oculi to the periosteum. This approach is good for correcting asymmetry and lateral hooding but the resulting incision may cause loss of the natural fine irregularity of the superior brow hair.

The endoscopic brow-lift is relatively new and limits the incisional complications of previously described approaches. Variations in endoscopic brow-lifting techniques have proliferated in the last several years and include subperiosteal, subgaleal, and combined subperiosteal and subgaleal central forehead dissections. Although the subgaleal approach has potential advantages, the subperiosteal lift remains more popular for several reasons. First, the optical cavity is ideal because of the relatively bloodless plane com-
pared with more superficial approaches. Second, bony landmarks are more easily visualized and helpful in orientation. Third, the periosteum is also more rigid and less relaxation of soft tissues is to be expected than in more superficial lifts. \(^1\)\(^3\)\(^4\)

The basic steps of endoscopic forehead rejuvenation include placing access incisions for instrumentation, undermining and mobilizing the forehead tissue, and then advancing, redraping, and fixating the tissue in an elevated position. In the subperiosteal endoscopic approach, lasting results rely on complete periosteal release and fixation of the brow in an elevated position during healing to allow pericranial reattachment to the underlying bone. Many fixation methods have been reported including anchoring sutures placed through fascia or through bone tunnels, sutures placed around absorbable screws, or temporary screws removed 7 to 14 days postoperatively. Others have used fibrin glue or no fixation at all. \(^3\)\(^5\)\(^6\) All methods report successful results. No objective studies have been done to quantify the optimal fixation time required, and studies addressing pericranial adherence specifically have not been performed. The purpose of this study was to determine the time required for pericranial readherence after surgical separation in the rabbit model.

**METHODS**

The study protocol was approved by the Institutional Animal Care and Use Committee. The initial study group consisted of 30 New Zealand white rabbits randomized into 10 groups. All animals were screened preoperatively for any obvious respiratory, cardiac, or systemic impairment. The first group served as the unoperated-on controls. They were immediately killed and a 1.0 \(\times\) 3.0-cm pericranial flap incised. Using a tensiometer (Digital Force Gauge model DFS-10 equipped with motorized test stand model LTCM; Chatillon, Greensboro, NC), the force required to separate the pericranium from the skull in the unoperated state was measured and recorded.

A cocktail of ketamine hydrochloride (5 mL, 100 mg/mL), xylazine hydrochloride (2.5 mL, 20 mg/mL), and acepromazine maleate (1 mL, 10 mg/mL) was administered as a subcutaneous injection at a dose of 1 mL/kg. The animals received a dose of preoperative antibiotic (enrofloxacin [Baytril], 2.5 mg/kg subcutaneously). The animal was placed in prone position and the forehead shaved and prepared. A coronal incision just anterior to the palpable frontal-parietal suture was made through the skin and soft tissue down through the periosteum. The periosteum was elevated bilaterally over the frontal, parietal, and occipital bones. The pericranium was then reapproximated in situ and the incision closed in layers, using 5-0 polyglactin 910 (Vicryl) interrupted sutures for the periosteum, muscle, and subcutaneous layers and 3-0 plain gut suture for skin closure. The animals were then recovered. Postoperatively, diet and activity were allowed ad libitum. Animals were observed daily for adequate pain control (feeding well, baseline activity level, able to perform self-care) and analgesics (buprenorphine hydrochloride, 0.02-0.05 mg/kg subcutaneously every 12 hours) was administered as necessary. Wounds were checked daily for signs of infection or dehiscence.

The operated-on rabbits were divided into 9 groups. Groups were killed on postoperative days 3, 5, 8, 10, 13, 17, 20, 25, and 28. The skin and soft tissues were then elevated and a 1.0 \(\times\) 3.0-cm flap of previously elevated pericranium was marked and incised. Using the tensiometer, the force necessary to separate the pericranium from the underlying bone at the time of sacrifice was measured and recorded.

The preliminary data were reviewed and there appeared to be significant differences in the measurements between groups killed on postoperative days 5, 8, and 13. Therefore, additional animals underwent pericranial elevation and were killed on postoperative days 5, 8, and 13, giving a total of 10 animals in each of these 3 groups. The data from the killed animals were analyzed using a 1-way analysis of variance and Scheffe post hoc tests.

The tensiometric measurement results are summarized below:

**RESULTS**

The mean force required to separate the pericranium in the control group was 211.67 g. The mean separation force required on postoperative day 3 decreased to 66.67 g and did not return to baseline strength until postoperative day 8 (mean, 175.5 g). A 1-way analysis of variance was performed on the force in grams required to separate the pericranium from the underlying skull (dependent variable) to look for effects of postoperative day or healing time (independent variable). A statistically significant effect of healing time exists \((P<.001)\). Scheffe post hoc tests were next performed to examine differences between individual postoperative days. There is a significant decrease in force required to separate the pericranium from the skull at 3 days \((P=.001)\) and at 5 days \((P<.001)\) compared with the control group (postoperative day 0). By postoperative day 8 and throughout the subsequent times examined, there were no statistically significant differences compared with the control group (Figure).

![Pericranial separation force (mean ± SD) over time.](https://archfaci.jamanetwork.com/)
COMMENT

Pericranial healing has been studied previously. In a study by Lo et al\(^9\) rabbit pericranial tissue was found to be revascularized 4 days after subperiosteal elevation. The authors used bone scanning with technetium Tc 99m methylene diphosphonate to assess revascularization but tensiometric adherence of the pericranial tissue was not addressed.

A more recent study by Romo et al\(^10\) examined periosteal fixation histologically after both endoscopic and bicoronal lifts in the rabbit model. They found increasing periosteal adherence over time with complete adherence by 12 weeks. Our study did not include histological assessment but rather examined the biophysical adherence between the pericranium and the underlying skull during the healing process. It is this reattachment that should provide the long-lasting elevation of the brow in actual clinical situations.

Of course, the results obtained in our rabbit model may not directly correlate with healing time in humans, but human studies of this nature would be impossible to perform. One of the major problems in studying rejuvenation surgery is the lack of objective data and measurement points when documenting results. Photographic documentation alone is operator and technique dependent and interpretation of results varies even under the most standardized conditions. Developing a measurement tool that can remove bias and standardize documentation will be key in analyzing results of brow rejuvenation surgery. Until then, quantifying the optimal fixation time in humans will remain difficult.

CONCLUSIONS

This study used a rabbit model to test pericranial adherence after subperiosteal elevation. By postoperative day 8, the pericranial adherence had returned to that of the control group. This study provides objective data regarding the time course for pericranial healing and provides preliminary information on the length of time fixation is necessary after subperiosteal brow-lifting. The information from this study may help the surgeon to choose a fixation technique and duration to achieve long-lasting brow-lifting results.

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REFERENCES