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ORIGINAL ARTICLE FACIAL SURGERY

Anatomic Comparison of Two Incision Designs on Scalp Advancement for Hairline Lowering Surgery

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Abstract

Background Hairline lowering (HALO) surgery is commonly performed using either a single anterior incision (AI) placed along the hairline or an anterior incision combined with bilateral extensions (BE) oriented anteroposteriorly along the superior temporal lines. The biomechanical implications of these incision designs remain insufficiently defined.

Methods Cadaveric dissections were performed on five heads. After placement of an AI and subgaleal release, maximal scalp advancement was measured in the midline and along both mid-pupillary lines. Subsequently, bilateral extensions were added, together with additional posterior subgaleal dissection and one additional galeotomy, and measurements were repeated. Statistical analysis compared advancement achieved with each incision design.

Results The BE design demonstrated greater scalp advancement at all measurement points compared with the AI design. Midline advancement increased by 21% ($P = 0.043$), right mid-pupillary advancement by 24.29% ($P = 0.048$), and left mid-pupillary advancement by 28.15% ($P = 0.048$). The most pronounced qualitative difference was observed at the lateral endpoints of the hairline, where BE allowed substantially greater advancement than AI; however, this observation was not quantitatively measured.

Conclusions This cadaveric study provides preliminary anatomical evidence suggesting that the BE incision design may allow greater scalp advancement than the AI technique, particularly at the lateral hairline endpoints. These findings should be interpreted with caution given the small sample size and the presence of additional release maneuvers in the BE group. Further clinical studies are warranted to validate these anatomical observations.

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Keywords Hairline-lowering surgery · Scalp advancement · Forehead reduction · Incision design

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Introduction

Hairline lowering (HALO) surgery is primarily indicated for female patients with a congenitally high frontal hairline [1, 2]. For the purposes of surgical planning, the canon of equal facial thirds serves as a valuable guideline: optimal facial balance is achieved when the forehead height approximates one-third of the total facial height [1, 2]. Anthropometric studies have demonstrated that a forehead exceeding this proportion is often perceived as less attractive and indicative of an older, more masculine appearance [3, 4].

Surgical hairline advancement is predominantly performed using one of two primary incision designs: (1) a Single Anterior Incision (AI) placed along the existing hairline, or (2) an Anterior Incision with Bilateral Extensions (BE) (Fig. 1), in which the anterior hairline incision is combined with bilateral extensions that run anteroposteriorly in proximity to the superior temporal lines [5–8]. The purpose of this manuscript is to enhance understanding of the biomechanics associated with these two designs through a cadaveric study. To our knowledge, this represents the first cadaveric study specifically evaluating the differences between incision designs for HALO surgery.

Materials and Methods

Study Design

To evaluate the differences in flap biomechanics associated with two distinct hairline incision designs, five fresh cadaveric heads were dissected in an anatomical laboratory. Both incisions were performed sequentially on each specimen, allowing direct within-specimen comparison of measurements taken before and after each dissection stage. Cadaveric characteristics including age, sex, ethnicity, scalp laxity, and prior surgical history were not available for this study; this represents an acknowledged limitation, as these variables may influence scalp mobility and advancement outcomes.

Dissection Technique

The dissection was performed by the first author under 2.5× loupe magnification using a standardized technique. Initially, an anterior incision was placed along the existing hairline, extending from one frontotemporal transition point across the entire forehead to the contralateral point. Blunt dissection was then carried out in the sub-galeal plane along the sagittal suture toward the anterior temporal line laterally, using a Ramirez dissector, carefully releasing areolar tissue and connective tissue adhesions as previously described by Bran et al. [9]. This dissection extended 3 cm beyond the vertex, as detailed by Epstein et al. [10].

Following this, two parallel galeotomies were placed with a #15 blade. The first was positioned approximately 20–25 mm posterior to the anterior edge of the hairline incision, and the second 15 mm posterior to the first. The released scalp was then advanced, overlapping the forehead skin. A line was drawn on the forehead to mark the anterior edge of the advanced AI-flap, representing the maximum possible advancement achievable with the AI design (see Fig. 2a). Measurements were subsequently taken along the mid-pupillary lines and in the midline. Marking and measurements were conducted by two examiners.

Next, on the same specimen, additional bilateral temporal incisions were introduced at the lateral endpoints of the original hairline incision (Fig. 3), as described by Kabaker [5]. These lateral extensions were 40 mm in length, slightly arched, and ran in proximity along the course of the superior temporal line on each side. The newly formed advancement flap allowed for full elevation of the scalp, which facilitated easier and more extensive subgaleal dissection toward the nuchal ridge, releasing all ligamentous attachments in the superoposterior scalp region [9]. One additional galeotomy was then placed 20 mm further posteriorly. The maximum scalp advancement achieved with the BE incision design was documented by drawing a new line across the forehead and repeating the measurements along the three lines of reference (see Fig. 2b).

It should be noted that the BE group differed from the AI group not only in incision pattern, but also in the extent of posterior dissection and the inclusion of one additional galeotomy. These additional release maneuvers independently contribute to increased scalp mobility. As a result, the study does not isolate the effect of incision design alone, and the observed biomechanical differences should be interpreted as reflecting the combined effect of incision configuration and expanded release maneuvers.

Statistical Analysis

All statistical analyses were performed using SPSS 23 (IBM, Armonk, NY, USA). The Shapiro-Wilk test was utilized to confirm normal distribution of data, and Levene's test was performed to verify homogeneity of variance. Quantitative features are reported as mean ± standard deviation. For non-parametric comparisons between groups, quantiles (Q1, Me, Q3) were employed. To compare measured features between the two surgical methods, either a paired t-test or Wilcoxon rank test was used, depending on the normality of data distribution. Given the small sample size, a bootstrap analysis with 1,000 iterations was conducted to estimate the confidence intervals of the mean differences between methods. Statistical significance was set at a P value of < 0.05. Given the small sample size ($n = 5$) and the complete agreement observed between both examiners during marking, interobserver reliability was not assessed by formal ICC calculation; instead, full concordance between examiners was noted qualitatively.

Results

Our findings demonstrate a statistically significant difference in hairline advancement between the AI and BE designs across all three measurement points.

In the midline, the average advancement for the AI design was 23.8 ± 5.3 mm, while the BE design achieved

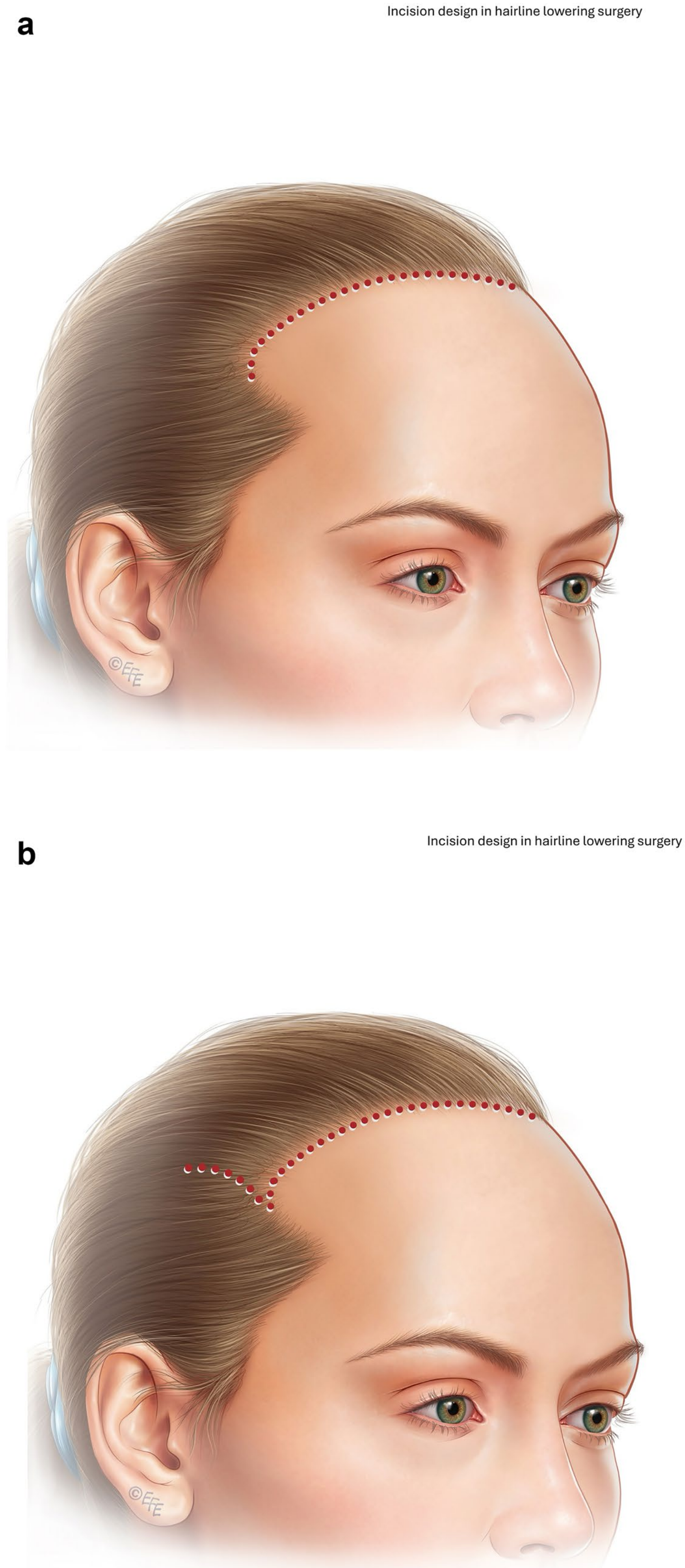
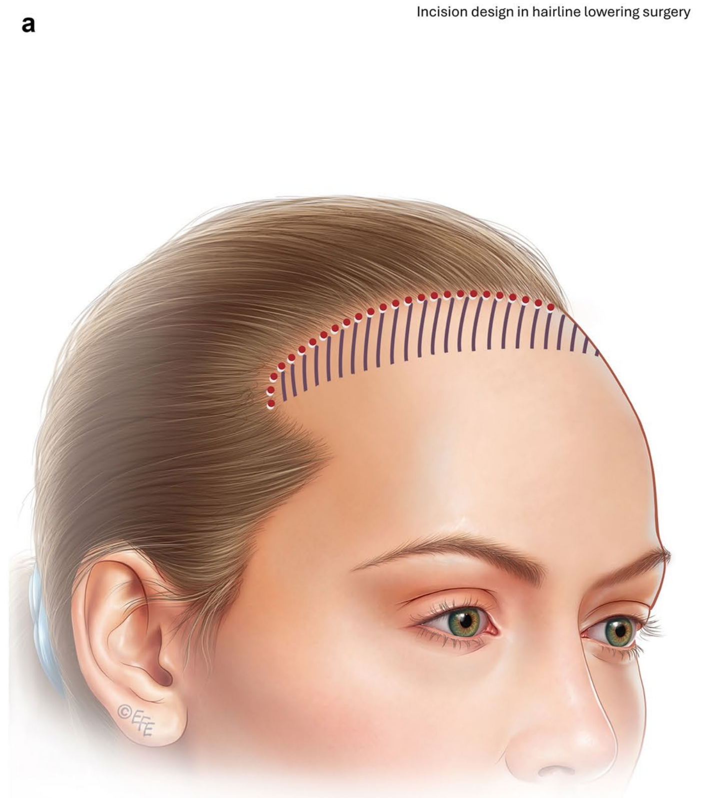


Fig. 1 **a** Illustration presenting the anterior incision design (AI), based on a single incision placed along the existing hairline. **b** Illustration presenting the bitemporal extensions incision design (BE). After completion of the anterior incision two additional incision were placed to the most lateral endpoints of the AI incision. These bitemporal incisions ran along the along the course of the superior temporal line

Fig. 2 **a** Illustration of the AI design and the resulting advancement of the scalp flap (shaded segment). **b** Illustration of the BE design and the resulting advancement of the scalp flap (shaded segment)



Incision design in hairline lowering surgery

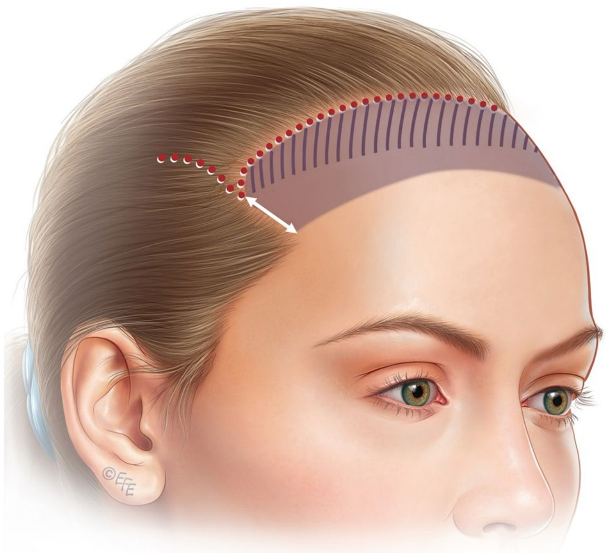


Figure 3.

Fig. 3 Comparing the maximum advancement of both incision designs revealed the greatest difference in scalp advancement at the lateral endpoints of the incision

28.8 ± 5.2 mm, representing a 21% increase (an additional 5 mm; *P* = 0.043).

Along the left mid-pupillary line, the AI design yielded an average advancement of 20.6 ± 4.7 mm, while the BE design achieved 26.4 ± 6.7 mm - an increase of 28.15% (an additional 5.8 mm; *P* = 0.048). Along the right mid-pupillary line, the AI design showed an average advancement of 21.4 ± 4.8 mm, and the BE design achieved 26.6 ± 6.4 mm - an increase of 24.29% (an additional 5.4 mm; *P* = 0.048).

There was no data point where the AI design advanced the hairline more than the BE design.

Bootstrap analysis (1,000 iterations) further substantiated these findings. The estimated mean differences (BE minus AI) were: left mid-pupillary line 5.79 mm (95% CI: 3.8–8.2 mm), center line 4.98 mm (95% CI: 2.2–8.2 mm), and right mid-pupillary line 5.16 mm (95% CI: 2.8–7.4 mm). As none of the confidence intervals include zero, these findings support statistically significant differences in advancement between the two designs (see Table 1).

Discussion

Hairline lowering (HALO) surgery is primarily indicated for female patients with a congenitally high frontal hairline. Secondary indications include acquired elevation of the hairline due to traction alopecia, perimenopausal thinning, or iatrogenic causes such as prior endoscopic browlift procedures. Although HALO surgery is performed less frequently in male patients, it may be considered in carefully selected individuals. In our clinical experience, male patients comprise less than 5% of those undergoing HALO surgery [11].

One of the defining characteristics of an aesthetically pleasing feminine hairline is a gentle, arched contour. The area where the anterior hairline meets the temporal hair - the temporoparietal transition zone - presents unique aesthetic and surgical challenges due to lower hair density, differences in hair quality, and a change in hair growth vectors. Many female patients seeking HALO surgery specifically identify this region as a concern [12, 13].

The present study was designed to compare the biomechanical characteristics of the AI and BE incision designs using a within-specimen anatomical approach, thereby minimizing inter-individual variability. The results demonstrated that the BE incision consistently permitted greater hairline advancement across all measured parameters, with statistically significant differences and confidence intervals that did not cross zero, reinforcing the reliability of these directional findings.

However, these results must be interpreted in context. The BE group not only differed in incision pattern, but also underwent additional posterior subgaleal dissection extending toward the nuchal ridge and the placement of one additional galeotomy. These maneuvers independently increase scalp mobility and likely contributed to the observed differences in advancement. Consequently, the study does not isolate the effect of incision design per se,

Table 1 Comparison between advancement for the anterior incision design (AI) and advancement of the anterior with bitemporal extensions design (BE). All measurements in mm

Side	AI					BE					p^*
	Mean	SD	Median	Q1	Q3	Mean	SD	Median	Q1	Q3	
Left	20.6	4.7	19.0	18.0	25.0	26.4	6.7	26.0	23.0	29.0	0.043
Center	23.8	5.3	21.0	20.0	29.0	28.8	5.2	30.0	26.0	30.0	0.043
Right	21.4	4.8	19.0	18.0	25.0	26.6	6.4	28.0	23.0	29.0	0.043

*Results were significant using both parametric and nonparametric tests for paired values. *P* values for non-parametric tests reported due to small sample size and the biomechanical advantage observed in the BE group should be understood as reflecting the combined effect of incision configuration and the expanded release techniques it facilitates.

Beyond the quantitative measurements, the most clinically significant difference between the two designs lies at the lateral endpoints of the hairline. In the AI design, the lateral endpoints function as fixed pivot points, limiting any inferior advancement of the lateral hairline. In contrast, the BE design creates a true advancement flap (Fig. 4), allowing for parallel forward movement of the entire anterior hairline, including its lateral aspects. Although this qualitative distinction was consistently observed across all specimens, it was not quantitatively measured in the present study - a limitation that should be addressed in future investigations through objective lateral advancement measurements or angular analysis.

Female patients with a high but naturally arched hairline may be adequately treated using the AI design. Conversely, patients presenting with a box-shaped or M-shaped hairline appear to benefit most from the BE incision design (Fig. 5). In our clinical practice, the BE technique is employed in approximately 40% of cases [14]. To our knowledge, this is the first cadaveric study specifically designed to evaluate the anatomical and mechanical differences between incision techniques used in HALO surgery.

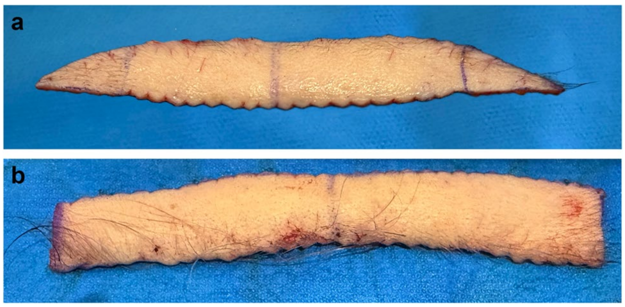


Fig. 4 **a** Specimen of forehead skin removed with the AI design. The lateral endpoints serve as pivot points, resulting in a sharp angulation with a more fusiform strip of resected skin. **b** The specimen of the BE design is a true advancement flap. The resected skin is rectangular, indicating the most significant difference to the AI design in the advancement of the lateral endpoints

Fig. 5 **a** Patient with an overly high forehead and an arched hairline. HALO surgery usually does not require any lowering of the lateral endpoints. HALO surgery in such a patient could be successfully achieved using the AI design. **b** Patient with an overly high forehead and a hairline which appears box-shaped: the central aspect of her hairline sits at the same level as the temporoparietal transition. A patient with such a hairline would benefit from the BE incision design. **c** Patient with an overly high forehead and a hairline which appears M-shaped: the central aspect of her hairline sits lower than the hair in the temporoparietal transition area. A patient with such a hairline would benefit from the BE incision design

Conclusion

This cadaveric study provides preliminary anatomical evidence that the anterior incision with bilateral extensions (BE) design allows greater scalp advancement than the single anterior incision (AI) across all measured reference points. However, given the small sample size ($n=5$) and the presence of additional release maneuvers in the BE group, these findings should be interpreted with caution, and conclusions of definitive superiority are not warranted at this stage.

Beyond the quantitative differences, the BE design facilitates true advancement of the lateral hairline segments, overcoming the fixed pivot limitation inherent to the AI technique and enabling a more harmonious, arched hairline contour. This qualitative advantage was consistently observed but not quantitatively measured, and represents an important area for future investigation.

These biomechanical observations appear particularly relevant for patients presenting with a box-shaped or M-shaped hairline, whereas patients with a naturally arched but high hairline may be adequately treated using the AI design. Further clinical studies with larger sample sizes are warranted to validate these anatomical findings and to assess their impact on long-term aesthetic outcomes and patient satisfaction [15–17].

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Declarations

Conflict of interest The author declares no potential conflicts of interest with respect to research, authorship, and publication of this article.

Ethical Approval This study was performed on human cadaveric specimens in accordance with institutional regulations governing the use of human anatomical material.

Informed Consent The use of cadaveric specimens complied with institutional regulations.

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