ORIGINAL ARTICLE

Cosmetic

Analysis of Hairline and Forehead Sexual Dimorphic Aesthetics in 60 Celebrities Using Artificial Intelligence

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Background: Upper facial third morphometrics are an important consideration in aesthetic facial surgery and facial gender-affirming surgery. Although there are generally accepted sexual dimorphic differences, an in-depth analysis of forehead morphometrics in attractive individuals is lacking.

Methods: Thirty white female and 30 white male celebrities were included. Three full-face front-view photographs of each celebrity were evaluated by a facial analysis program, using Vision framework and MATLAB. After converting pixel distances to absolute distances, midline and lateral forehead heights were calculated and compared between men and women.

Results: Forehead height was similar between attractive men and women, but forehead width was shorter in women. Analysis of forehead height at various points along the hairline demonstrated that forehead measurements above the lateral brow and brow peak were significantly greater in men. Mean forehead height above the lateral eyebrow was 3.51 cm in women and 4.16 cm in men ($P = 0.017$). Forehead height above the eyebrow peak was 4.34 cm in women and 5.55 cm in men ($P < 0.001$). Medial forehead height was similar between men and women, indicating that the greatest difference in attractive male and female foreheads is in the lateral forehead and forehead width.

Conclusions: Analysis of attractive white celebrities demonstrated no significant differences in central forehead heights between men and women. Forehead width and lateral forehead height were significantly smaller in women, with an overall downward slanting contour. Male hairlines were more horizontal and slanting upward laterally. These results have implications in facial rejuvenation and facial gender-affirming surgery. (*Plast Reconstr Surg Glob Open 2023; 11:e5107; doi: 10.1097/GOX.0000000000005107; Published online 6 July 2023.*)

INTRODUCTION

Morphometrics of the upper facial third play an important role in facial beauty. Men and women exhibit distinctive features of the upper facial third that influence facial analysis and planning in aesthetic facial surgery, facial gender-affirming surgery (FGAS), and hair transplantation. Forehead and hairline shape are distinct in men and women.[1–3] Classically, men have an M-hairline shape with varying degrees of frontotemporal recession.[4,5] Although previously thought to be mostly round, the female hairline is distinct from men and has been shown to be more complex; 81% of women have a widow's peak, 98% have lateral temporal mounds, and 64% have cowlicks. The male forehead exhibits a more prominent glabella and supraorbital rim, whereas the female forehead has a smoother contour with more subtle bony landmarks.[3,6]

FGAS is an important part of transgender care and has been shown to increase patient satisfaction with their facial appearance.[7] Spiegel[8] reported that forehead feminization has the strongest association with femininity of the overall face when compared with feminization procedures of the mid or lower face. The authors identified glabellar prominence, eyebrow shape and position, and hairline shape as the three contributors to defining the upper third.

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Previous studies have analyzed morphometric differences of the upper facial third on the average man and woman; however, forehead analysis in attractive individuals has been limited to the comparison of forehead height.[9] Given the influence of pop culture icons on current trends in aesthetic facial rejuvenation, we aimed to analyze forehead morphometrics and hairline aesthetics in attractive white male and female faces.

METHODS

Thirty white female and 30 white male celebrities and models were included in this study. This list was generated using GQ magazine's "Highest Paid Models" issue, celebrities featured on the covers of People Magazine's "Beautiful" issue (1991–2022), and celebrities featured on lifestyle websites. The average age of female celebrities at the time of their photograph was 29 (standard deviation, 5.68 years; range 20–40 years). The average age of male celebrities was 31 (standard deviation, 6.46 years; range 18–46 years). For each celebrity, three photographs were analyzed. To mitigate any discrepancies in photographic standards or potential digital manipulation, all photographs were reviewed by three independent graders, including the senior author (B.A.S.). We utilized photograph sources, such as Getty Images, Shutterstock, and Alamy to select many of the photographs. Most photographs were from formal entertainment events and taken by professional photographers present at the events, as stated in the photograph credits. Inclusion criteria of images include full-face, front-view photograph, visible hairline and facial contour, and minimal facial animation.

Facial landmarks were detected through a custom, semiautomatic facial analysis program using Vision framework, Apple's computer vision algorithm. Additional custom points were added through custom-programmed MATLAB software. Pixel distances were converted to absolute measurements by dividing the pixel measurement by the subject's white-to-white corneal diameter in pixels.[10] The ratio was then multiplied by the accepted mean white-to-white corneal diameter in millimeters (11.71±0 0.42 mm in white subjects).[10] To validate this method of pixel conversion to absolute measurements, 78 facial measurements were taken on six volunteers, using this method and compared with manual measurements obtained from subjects' photographs that contained a reference ruler for scale. The average difference between the two measurements obtained was 1.17±1.14 mm.

Measurements and proportions of the face and midline and lateral forehead were calculated using the eyebrow as a point of reference (Fig. 1). Facial rotation was accounted for by calculating an overall face rotational angle for each photograph and measuring the angle between the median face vector (glabella to menton) and the vertical vector. If the angle was positive, it indicated that the face was turned clockwise relative to the vertical vector, and the face rotation was corrected to a neutral position.

Statistical analysis was performed with Blue Sky Statistics (BlueSky Statistics LLC, version 7.40, Chicago, Ill.), a statistical analysis software, to determine the mean,

Takeaways

Question: What are the sexually dimorphic differences in forehead measurements of attractive individuals?

Findings: Forehead width was significantly smaller in attractive women compared with attractive men. Forehead measurements above the lateral brow and brow peak were significantly greater in men. Mean forehead height above the lateral eyebrow was 3.51 cm in women and 4.16 cm in men. Forehead height above the eyebrow peak was 4.34 cm in women and 5.55 cm in men.

Meaning: Forehead width and lateral forehead height were significantly shorter in women. Female hairline had an overall downward slanting contour whereas the male hairline was more horizontal with a slight upward slant.

standard deviation, and P values of the measurements and ratios in men and women. Values of P less than 0.05 were considered statistically significant.

Six eyebrow (EB) points (p) were identified:
- EB p1 and EB p6 corresponded to the lateral end of the right and left eyebrow, respectively.
- EB p2 and EB p5 corresponded to the right and left eyebrow peaks, respectively.
- EB p3 and EB p4 corresponded to the medial end of the right and left eyebrow, respectively.

Nine points along the hairline (HL) were identified:
- HL p1 and HL p9 were the most lateral right and left hairline points and were located at the same horizontal level as that of the the glabella, EB p3, and EB p4.
- HL p2 and HL p8 were at the same vertical level as that of the the lateral ends of the eyebrow, EB p1 and EB p6, respectively.
- HL p3 and HL p7 were at the same vertical level as that of the the eyebrow peaks, EB p2 and EB p5, respectively.
- HL p4 and HL p6 were at the same vertical level as that of the the medial ends of the eyebrows, EB p3 and EB p4, respectively.
- HL p5, also the trichion, was at the same vertical level as that of the the glabella.

Seven vertical forehead (FH) measurements (M) were taken from the hairline to the eyebrows bilaterally.
- FH M1 and FH M7 were the forehead heights above the lateral ends of the eyebrows, from HL p2 to EB p1 and from HL p8 to EB p6, respectively.
- FH M2 and FH M6 were the forehead heights above the eyebrow peaks, from HL p3 to EB p2 and from HL p7 to EB p5, respectively.
- FH M3 and FH M5 were the forehead heights above the medial ends of the eyebrows, from HL p4 to EB p3 and from HL p6 to EB p4, respectively.
- FH M4 was the distance from the trichion (HL p5) to the glabella. FH M4 is also the central forehead height.

Two forehead widths were calculated. Superior forehead width was calculated as the distance between HL p3 and HL p7, which are above the eyebrow peaks. Lower forehead width was calculated as the distance between HL p1 and HL p9, which are at the same horizontal level as the
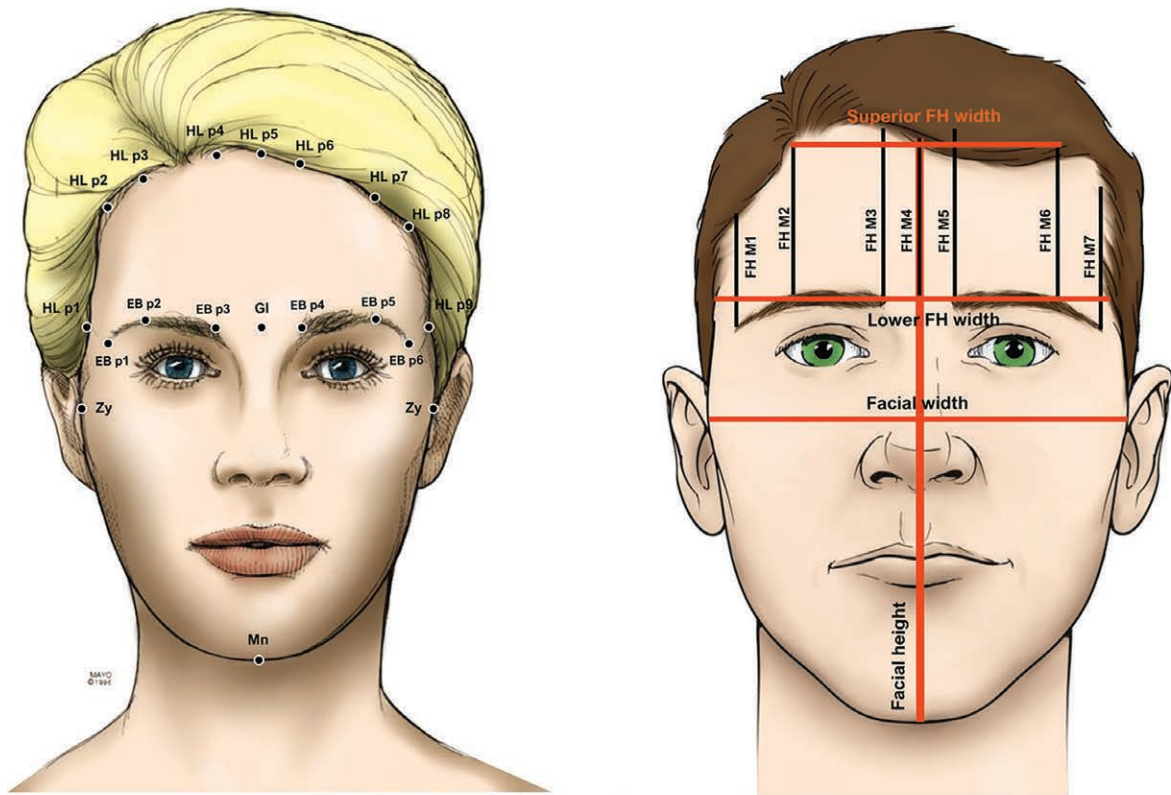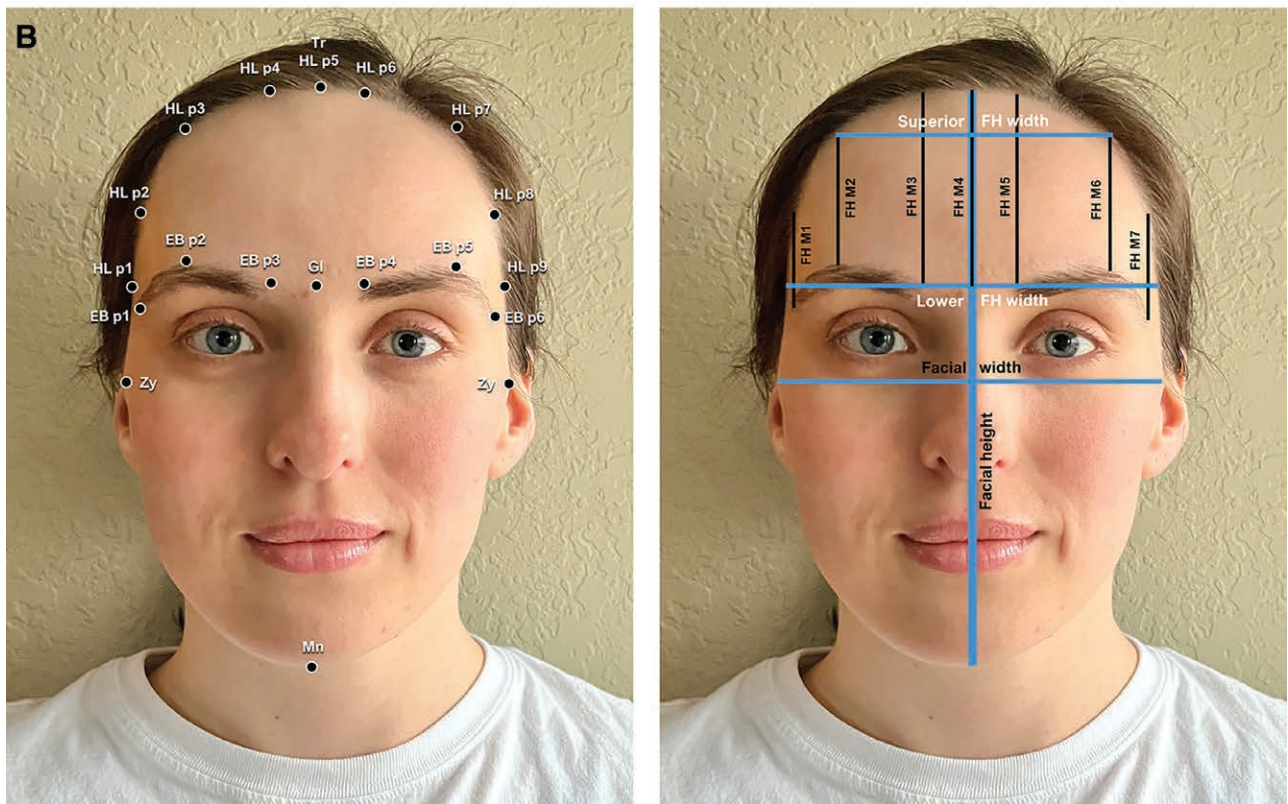
Fig. 1. Facial landmarks and forehead measurements of interest. Landmark points demonstrated on illustrations (A) and on a human face (B). HL, hairline; EB, eyebrow; Gl, Glabella; Zy, zygoma; Mn, menton; FH, forehead; p, point; M, measurement. Figures 1A-1B adapted with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

glabella and the medial eyebrow points (EB p3, EB p4). Median and paramedian forehead heights were defined by FH M3-M5. Lateral forehead heights were defined by FH M1-2 and FH M6-7.

Mean hairline shapes of the men and women were created. Mean forehead heights (FH M1 through FH M7) for women and men were applied to representative eyebrow illustrations to determine hairline points over the lateral brow, brow peak, medial brow, and glabella.

RESULTS

The female celebrities in our study were Liv Tyler, Charlize Theron, Uma Thurman, Sarah Jessica Parker, Hilary Swank, Gisele Bundchen, Drew Barrymore, Mila Kunis, Ginnifer Goodwin, Charlotte Church, Hayden Panettier, Demi Lovato, Keira Knightley, Olivia Wilde, Demi Moore, Katie Holmes, Anna Kendrick, Ashley Greene, Kim Raver, Reese Witherspoon, Cheryl Cole, Ashley Graham, Bella Hadid, Catherine Zeta Jones, Christina Applegate, Jennifer Garner, Julia Roberts, Kate Hudson, Kendall Jenner, and Gigi Hadid. The male celebrities in our study were Adam Levine, Blake Shelton, Bradley Cooper, Channing Tatum, Chris Hemsworth, David Beckham, Leonardo DiCaprio, Mel Gibson, Arthur Kulkov, David Gandy, Jon Kortajarena, Sean O'Pry, Tobias Sorenson, Noah Mills, Ollie Edwards, Paul Rudd, Ryan Burns, Ryan Reynolds, Simon Nessman, Tom Cruise, Tyson Ballou, Chris Evans, Johnny Depp, Hugh Jackman, Matt Damon, George Clooney, Matthew McConaughey, Ben Affleck, Pierce Brosnan, and Brad Pitt.

Table 1 demonstrates the mean forehead measurements. Table 2 demonstrates the ratios. Facial height and width were significantly greater in the attractive men compared with the attractive women (facial height: 19.36 cm in men, 18.23 cm in women, $P < 0.001$; facial width: 14.15 cm in men, 13.51 cm in women, $P < 0.001$). The mean facial height to facial width ratio (R1) was slightly higher in men, but there was no significant difference in this ratio between the male and female faces.

Central forehead height (FH M4) was similar between men and women, but superior and lower forehead widths were statistically significantly shorter in female faces. Superior forehead width was 9.52 cm in men and 8.96 cm in women. Lower forehead width was 13.61 cm in men and 13.25 cm in women ($P = 0.005$). The forehead height to superior forehead width ratio (R2) was statistically smaller in men compared with women (0.61 in men, 0.65 in women, $P < 0.001$). The forehead height to lower forehead width ratio (R3) was also statistically smaller in men ($P = 0.013$); however, the ratios themselves were similar (0.43 in men, 0.44 in women). Additionally, the facial

Table 1. Mean Face and Forehead Measurements in Attractive White Women and Men

Measurements	Points	Women Avg (cm) n = 30	Men Avg (cm) n = 30	P
Facial height	Trichion-Menton	18.23 (±1.08)	19.36 (±1.40)	<0.001*
Facial width	Zygoma-Zygoma	13.51 (±0.82)	14.15 (±0.86)	<0.001*
FH height (FH M4)	Trichion (HL p5)-Glabella	5.86 (±0.59)	5.77 (±7.32)	0.386
Superior FH width	HL p3-HL p7	8.96 (±0.64)	9.52 (±0.92)	<0.001*
Lower FH width	HL p1-HL p9	13.26 (±0.95)	13.61 (±0.85)	0.005*
FH M1	HL p2-EB p1	3.53 (±1.14)	4.17 (±1.73)	0.018*
FH M2	HL p3-EB p2	4.39 (±0.82)	5.58 (±0.79)	<0.001*
FH M3	HL p4-EB p3	6.02 (±0.59)	6.04 (±0.64)	0.718
FH M5	HL p6-EB p4	6.01 (±0.58)	6.02 (±0.68)	0.909
FH M6	HL p7-EB p5	4.30 (±0.80)	5.52 (±0.79)	<0.001*
FH M7	HL p8-EB p6	3.49 (±1.06)	4.14 (±1.67)	0.015*
Avg of FH M3 and FH M5		6.01 (±0.58)	6.03 (±0.65)	0.742
Avg of FH M2 and FH M6		4.34 (±0.80)	5.55 (±0.77)	<0.001*
Avg of FH M1 and FH M7		3.51 (±1.09)	4.16 (±1.68)	0.017*

*Significant P values ($P < 0.05$).
Avg, average; EB, eyebrow; M, measurement; p, point; FH, forehead; HL, hairline.

Table 2. Ratios of the Face and Forehead in Attractive White Women and Men

Ratios	Measurements	Women Avg (n = 30)	Men Avg (n = 30)	P
R1	Facial height/facial width	1.35 (±0.06)	1.37 (±0.07)	0.157
R2	FH height/superior FH width	0.65 (±0.07)	0.61 (±0.08)	<0.001*
R3	FH height/lower FH width	0.44 (±0.04)	0.43 (±0.05)	0.013*
R4	Facial height/FH height	3.13 (±0.21)	3.38 (±0.28)	<0.001*
R5	Facial width/lower FH width	1.02 (±0.03)	1.04 (±0.03)	<0.001*
R6	Facial height/lower FH width	1.38 (±0.08)	1.42 (±0.09)	<0.001*
R7	FH M4/Avg of FH M3 and FH M5	0.97 (±0.03)	0.96 (±0.04)	<0.001*
R8	FH M4/Avg of FH M2 and FH M6	1.39 (±0.24)	1.07 (±0.33)	<0.001*
R9	FH M4/Avg of FH M1 and FH M7	1.85 (±0.64)	1.64 (±0.70)	0.009*

*Significant P values ($P < 0.05$).
Avg, average; FH, forehead; M, measurement; R, ratio.

height to forehead height ratio (R4) was significantly greater in attractive men compared with attractive women ($P < 0.001$), with the female forehead heights approximating the described horizontal facial thirds (3.13), whereas men tended to deviate more from uniform facial thirds (3.38; Fig. 2). Given that male and female forehead height values were similar (5.77 cm and 5.86 cm, respectively), these results demonstrate greater absolute facial height in men compared with women.

The ratio of facial width to lower forehead width (R5) was significantly greater in attractive male faces (1.04) compared with attractive female faces (1.02, $P < 0.001$; Fig. 3). The ratio of facial height to lower forehead width (R6) was also significantly greater in men (1.42) compared with women (1.38, $P < 0.001$; Fig. 4).

Further analysis of the median seven forehead measurements demonstrated that forehead heights above the medial brow (Avg of FH M3 and FH M5) and glabella (FH M4) were not significantly different between the two cohorts. However, mean female forehead height at the level of the eyebrow peak (Avg of FH M2 and FH M6) was 1.21 cm shorter than in the men ($P < 0.001$). At the lateral
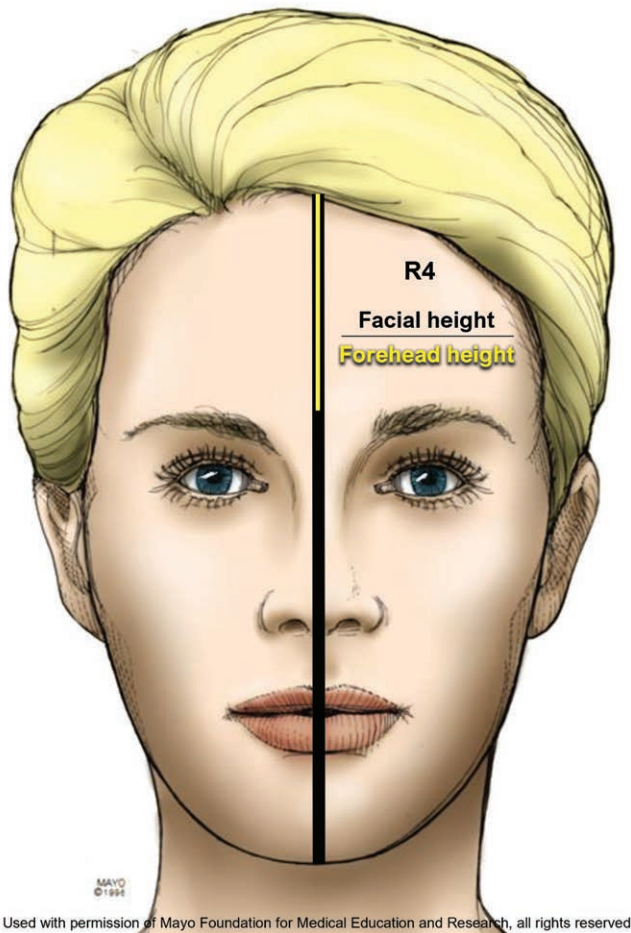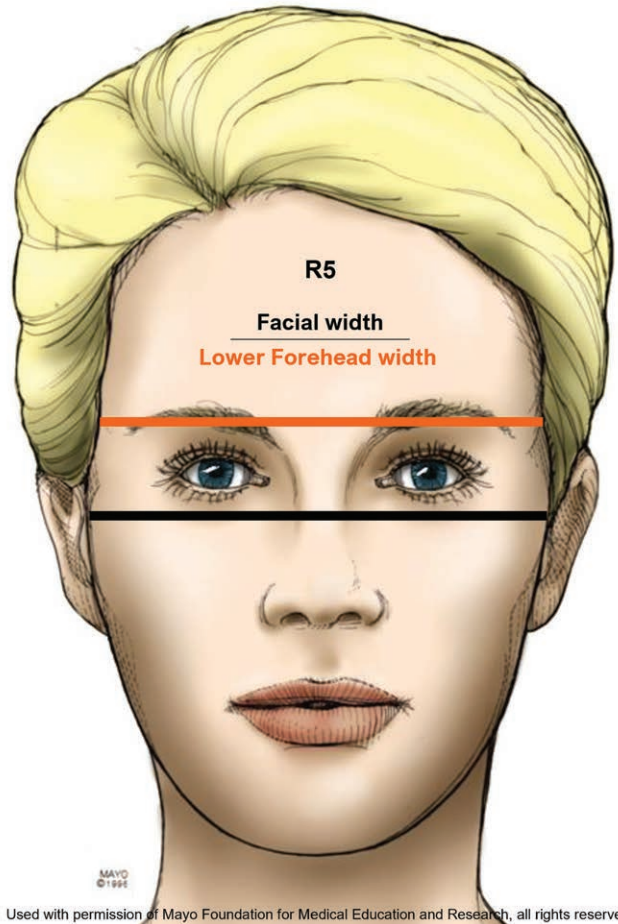
Fig. 3. The ratio of facial width to lower forehead width (R5): 1.04 in men and 1.02 in women (*P* value <0.001). Adapted with permission from Mayo Foundation for Medical Education and Research, all rights reserved.

end of the brow, mean male forehead height (Avg of FH M1 and FH M7) was approximately 0.65 cm longer than in the women ($P = 0.017$).

The seven vertical forehead measurements used to create a visual representation of the mean hairline contour of the female and male celebrities are shown in Figure 5. The female hairline had a downward hairline slope from medial brow to the brow peak, whereas men had a horizontal or upward slope, creating a distinct M-shape.

DISCUSSION

Forehead height from the trichion to the glabella has been reported as 6–7 cm in the average woman and 7–8 cm in the average man.[4,11] In a study comparing multiracial celebrities to anonymous volunteers, forehead height was found to be 7.64 cm in attractive women compared with 7.23 cm in average women, whereas attractive men had an average forehead height of 7.12 cm compared with 6.87 cm in average men.[9] The values were significantly different between attractive men and women and between the average men and women. A study by Yalcinkaya et al[9] included celebrities of different races and ethnicities, and
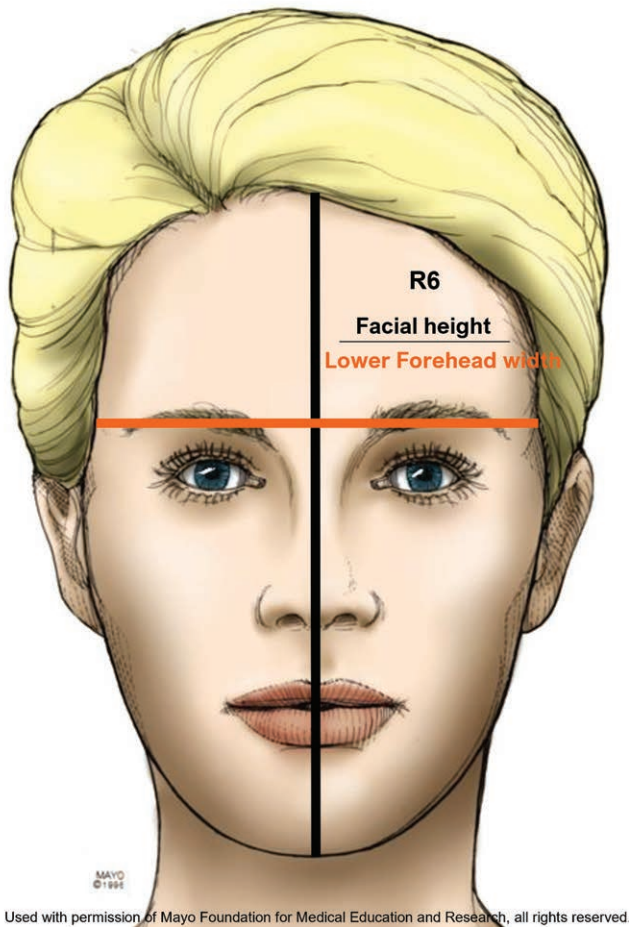
Fig. 2. The ratio of facial height to forehead height (R4): 3.38 in men and 3.13 in women (*P* value <0.001). Adapted with permission from Mayo Foundation for Medical Education and Research, all rights reserved.

Fig. 4. The ratio of facial height to lower forehead width (R6): 1.42 in men and 1.38 in women (*P* value <0.001). Adapted with permission from Mayo Foundation for Medical Education and Research, all rights reserved.

so a greater heterogeneity of facial shapes was analyzed. On the other hand, our study focused on white faces only.

We found the mean central forehead height (FH M4) to be slightly shorter in attractive white men compared with that in women (5.77 cm and 5.86 cm, respectively); however, the difference was not statistically significant. This indicates that central forehead height does not provide the most meaningful information on masculinity or femininity of the face. In addition, mean central forehead height in the faces studied was less than 6 cm in both attractive men and women.

The eyebrow can serve as a reference for other facial features, and it was used as the inferior border in our forehead measurements. The eyebrows, together with the anterior hairline, form a frame for the upper face, and the shape of this frame may impact the perception of facial gender, age, and beauty.[12] The two central forehead heights, which were the height above the glabella and the height above the medial end of the eyebrow, were similar in male and female celebrities. However, the two lateral forehead heights, which were the height above the eyebrow peak and the height above the lateral eyebrow, were

significantly shorter in women compared with in men. This demonstrates that the lateral forehead height ratio to central forehead seem to play a bigger role in defining the gender of a face than absolute forehead height. These results serve as a guideline for anterior hairline design in hair transplantation and when planning brow lift procedures and incision placement in FGAS. Furthermore, these forehead findings imply that the median and paramedian portion of the female hairline can be quite varied and still be considered aesthetic. Overall, examination of the mean hairline shape of attractive men and women demonstrated a downward slope in the anterior hairline from the midline to lateral brow in women and a horizontal or even slight upward slope in men, emphasizing an M-shaped hairline (Fig. 5). It should be noted that the celebrities analyzed in this study were in their late twenties to early thirties; so our results are representative of a young adult population. When planning forehead rejuvenation and FGAS in older patients, the amount of hairline advancement may be more conservative than the results reported here.

One of the neoclassical canons is the rule of horizontal thirds. According to the canon, the ratio of facial height to forehead height (R4) should be 3, and we observed R4 to be 3.13 in attractive women and 3.38 in attractive men (*P* < 0.001) (Fig. 2). This indicates that attractive female faces more closely adhered to the rule of horizontal facial thirds than attractive male faces. Much variation from the neoclassical canons has been shown, but symmetry in proportions is still considered a factor of facial attractiveness.[13–16]

With aging, the forehead and hairline also experience changes, primarily hairline recession at the temporal regions. There has been an increase in women seeking hair restoration surgery as a result of congenitally high hairlines, hairline recession, deformities caused by trauma or surgery, and traction alopecia.[2,5] The provided forehead height ratios (R7–R9) in attractive men and women may offer a guide for foreheadplasty.

We conducted our facial analysis using photographs of white celebrities, as previous studies have shown that there are morphometric differences between people of different races. However, it is important to note that the white population consists of individuals of different ancestry, including German, French, Italian, Irish, and many others. We report our findings as a guideline that surgeons can utilize when performing facial surgery on white patients, while also considering the rest of the patient's facial features to preserve harmony of the face.

One limitation of this study was that the photographs were not taken at the same camera shooting position, as they were obtained from online sources. However, we were extremely careful when screening the photographs. Three photographs of each celebrity were evaluated to ensure that the measurements were as standardized as possible. Most photographs chosen were photographed at major entertainment events and were taken by professional photographers based on the photograph credits from photographic sources. Additionally, each photograph was evaluated by three independent graders, including the senior author (B.A.S.). To correct for any deviation from a full front-view photograph, we used the average of the
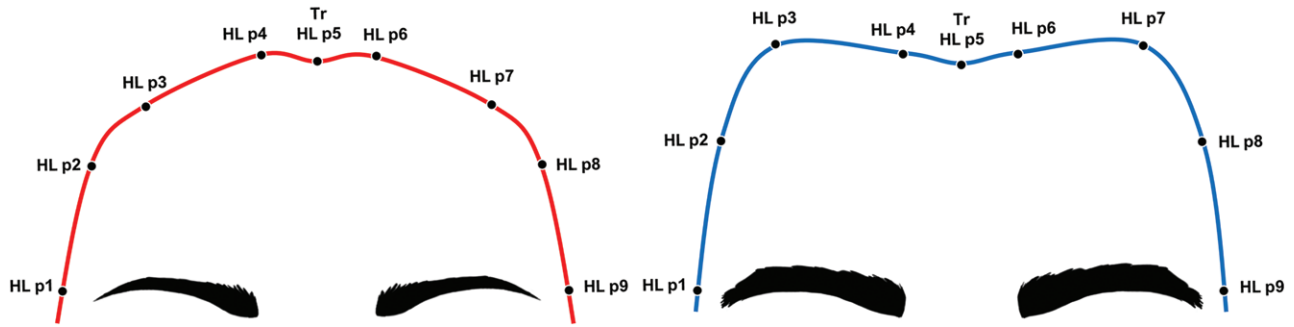
Fig. 5. The mean hairline shape of attractive white men and women.

corresponding right and left facial measurements for our analysis.

Another limitation is that neuromodulation and surgical or nonsurgical alteration of brow position cannot be confirmed in the photographs. However, any changes to the brow position or hairline would have been done to reflect the current idea of a beautiful face, as these celebrities were selected from lists identifying them as attractive individuals. Furthermore, the celebrities included were young at the time of their photographs (average age of women, 29; average age of men, 31), and so hairline recession at this time is likely minimal.

CONCLUSIONS

Analysis of attractive white celebrity faces demonstrated no significant differences in central forehead heights between men and women. However, forehead width and lateral forehead height were significantly shorter in women. Female hairline silhouette had an overall downward slanting contour from central to lateral. Male hairline shape was more horizontal with a slight upward slant from central to lateral. These results have implications in facial rejuvenation, hair transplantation, and FGAS.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

The patient provided written consent for the use of her image.

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