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The Lateral Brow: Position in relation to age, gender and ethnicity

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Abstract

Purpose—Despite multiple studies regarding modes of eyebrow measurement and movement over time, the lateral aspect of the brow has been relatively ignored in literature. Therefore, we arranged a study of the most lateral aspect of the eyebrow; in doing so, we hoped to ascertain the most practical line or angle of measurement.

Methods—In this cross-sectional study, adults aged 18 and older with no history of congenital or acquired periorbital or orbital pathology or surgery; brow tattooing or heavy plucking; phthisis; or strabismus were measured using a combination of in-office metrics and computer analysis. Subjects were asked to identify their ethnicity and country of origin. Models of age, gender, age and ethnicity were created.

Results—1024 subjects were included (1944 eyes). Measurements of nasal ala to lateral brow (NALB), lateral brow plumb line (LBPL, the vertical line between the tail of the brow and a horizontal line extending from the lateral canthus), and angle from the mid-brow to the lateral brow tail all showed statistically significant decline over time. The angle and LBPL varied most by ethnicity. The angle narrowed approximately 3 degrees per 20 years, while the LBPL fell approximately 2.5 mm per 20 years. The NALB varied most by age, and fell approximately 3 mm per 20 years.

Conclusions—The lateral tail of the brow descends with age. Measurements of its location and rate of change vary between genders and within ethnic groups. Two easily measured values – NALB and LBPL – can be used for pre-operative planning and post-operative documentation.

The aesthetic of the lateral eyebrow has been a subject of varied description in the medical literature. While some align the lateral brow along the same horizontal plane as the medial aspect of the brow, and align both with their respective canthi,¹ others note that, it is the

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apex of the brow that should be aligned with the lateral canthus,² or find that the lateral brow tail dips below the depth of the medial brow.³

The ideal aesthetic is further complicated by the known impact of the age of the patient in question; younger patients favor lower brows with more laterally placed arches; older patients favor higher brows with more centrally placed arches.⁴ This difference in aesthetic ideals may be influenced both by trends⁴ and by the natural course of brow movement over time.⁵

Causes of lateral brow movement over time appear to be multiple. The lateral aspect of the brow is not bound to the supraorbital ridge via fatty and fibrous connective tissue, as opposed to the rest of the brow, theoretically allowing it to descend with other soft tissues over time.⁶ In addition, the lateral brow is pulled by competing muscle forces surrounding the temporal fusion line.⁷ Chronic frontalis use may actually elevate the entire eyebrow/eyelid complex over time.^{8,9} Furthermore, there is likely an interplay between age-related bony changes of the supraorbital rim and loss of elasticity and thinning of the skin creating the appearance of brow deflation.¹⁰

However, despite the multiple studies regarding the ideal brow aesthetic and the movement of the eyebrow over time, we have not been able to locate an English language study regarding the movement of the most lateral aspect, or the tail, of the brow over time. It is thus unclear what the normative values of lateral brow placement are for any given age range. Nor is it clear what method of measurement ought to be used to define these values.

We therefore arranged a study of the most lateral aspect of the eyebrow, with the intention of more accurately defining the location of this part of the brow in different age, gender and ethnic groups. In doing so, we also hoped to ascertain the most practical line or angle of measurement.

Materials and Methods

Our institutional review board approved our cross-sectional study. Any clinic patient older than 18 was considered for enrollment. Exclusion criteria were limited to a history of brow, ocular, orbital or periorbital surgery, trauma, or tumors; brow tattooing or heavy brow plucking; phthisis; strabismus; and congenital craniofacial abnormalities. Patients were enrolled and consented during the course of their clinic appointment, prior to instillation of dilating eye drops. At that time, they subjectively identified both their country of origin and their ethnicity, choosing among Caucasian, Black, Hispanic, and Other.

In the primary position of gaze using a flexible millimeter ruler and a muscle light directed to illuminate and clarify the center of the pupil, the following measurements were taken (see Figure 1): mid-pupil to upper lid margin (MRD1); mid-pupil to mid brow, defined as the inferior-most row of mature brow hairs; nasal ala to lateral brow tip, defined as the lateral-most mature brow hair; and “lateral brow plumb line”, which was measured as a vertical line from the tip of the tail of the brow to a reference horizontal line going through the lateral canthus. Care was taken to ensure that the subject’s frontalis muscle was relaxed throughout these measurements; specifically, careful observation was used to ensure forehead

relaxation; subjects were asked to close their eyes and gently open them prior to measurements, and digital massage was used to relax the frontalis muscle as needed.

Participants were also photographed in frontal and oblique views from a distance of 4 feet, with standardized zoom and automatic focus, allowing for a clear image of the eyebrows, eyes and nose; a reference millimeter ruler was held at the cheek. The following digital cameras were used: Canon Powershot Elph300HS, Kodak Easyshare z915, and Kodak Easyshare Max Z990. Digital photographs were analyzed using a free National Institute of Health image processing and analysis program, ImageJ (<http://rsbweb.nih.gov/ij/>). Using the ImageJ computer program, the angle formed by the line from mid-pupil to mid-brow and a line from that same point at the mid-brow to the lateral brow was calculated digitally (see Figure 2).

The five measurements described above were generally performed on both eyes, though if the subject was called for a scheduled clinic examination or had a history of surgery in one eye, only one eye was measured. Because the majority of subjects had both eyes measured, measurements were expected to be highly correlated within individuals and as a result, standard linear regression approaches that assume independent observations are not appropriate for our data. To adjust for this correlation, all regression modeling was performed using the generalized least squares (GLS) method, assuming a compound symmetry covariance structure between repeated eye measurements within individuals and homoscedastic variance. Four main types of regression models were fit using the following covariates: a) single continuous age, b) continuous age, nominal gender and interaction with age, and c) continuous age, nominal ethnicity and interaction with age, and d) continuous age, nominal gender, nominal ethnicity plus interactions between the three. Models of type (c) and (d) were refitted for all different ethnicity/gender combinations as the reference group in order to detect significant differences between their intercepts and age slopes. All analyses were performed using the open-source statistical analysis software R (<http://www.r-project.org/>), version 2.15.0. GLS models were fit using the `gls()` function in package "nlme" ("non-linear mixed effects") and figures were generated using the "base" packages. All analyses were two-tailed. When appropriate, p-values ≤ 0.05 were considered statistically significant ($\alpha = 0.05$).

Results

1024 subjects were included in our study (1944 eyes). For further demographic breakdown, please see Tables 1 and 2. Statistical analysis was performed in order to compare mean measurements and their change with age for subjects with only one eye measured to those with both eyes measured, and no statistically significant difference was found in any model. Thus, subjects with either one or both eyes measured were kept in the final analysis. Additionally, the group containing Other ethnicities was used in the overall analysis, but was not included in other tables or graphs here given the small number and lack of theoretical ethnic similarities.

Reference measurements: Grouped analysis

Mid-Pupil to Upper Lid Margin (MRD1)—The average MRD1 appeared to decrease with age by 0.01mm per year; while this decline did not achieve statistical significance overall ($p=0.14$), it was found to do so in Caucasian males ($p=0.03$). For averages in 20-year age groups, please see Table 3. Overall data showed averages of 3.5mm up to age 60, with a decline to 3.1mm in subjects 61 and older. As seen in Figure 3, a small difference in starting measurement was noted when comparing males and females, but by the oldest age group, the two genders approached equal measurements; there was no statistically significant difference between genders. Plots of MRD1 versus mid-pupil to mid-brow height and MRD1 versus the lateral brow plumb line did not show a correlation.

Mid-Pupil to Mid-Brow—The average mid-pupil to mid-brow distance appeared to decrease with age by 0.03 mm per year, but this did not reach statistical significance ($p=0.18$). For averages in 20-year age groups, please see Table 3. Overall measurements showed a small trend downward over time from an average of 14.1 mm average in the youngest age group to 13.1mm in the oldest age group. As seen in Figure 4, males and females showed a similar slight decline with age. Female average distances were approximately 3mm greater than their male counterparts, meaning that the female brow starts off approximately 3 mm higher centrally than male counterparts. However, this difference did not achieve statistical significance. Caucasians had a statistically significant lower intercept measurement ($p=0.002$) than the other ethnic groups, meaning that Caucasian mid-brow seems to start off in a lower position compared to the other groups. In contrast to the other ethnic groups, the Caucasian population also showed increasing average measurements over time ($p=0.03$).

Key Measurements: Complex analysis

Nasal Ala to Lateral Brow Tail

Grouped Analysis: The average nasal ala to lateral brow distance decreased by 0.15mm per year ($p<0.001$). For averages in 20-year age groups, please see Table 3. Overall data decreased by just over 3mm per 20-year age group. As seen in Figure 5, male and female averages begin and end at essentially equivalent measurements.

Ethnicity Analysis: We modeled gender, ethnicity and age together. As seen in Figure 5, ethnicity did not appear to play a significant role in the decline of this measurement over time, and this lack of significance was confirmed in statistical analysis. There was a trend towards a slightly greater decrease in this measurement with time among females compared with males in each ethnic group, although this did not reach significance.

Lateral Brow Plumb Line

Grouped Analysis: The average vertical distance between the tail of the lateral brow and a horizontal line through the lateral canthus decreased by 0.1mm per year ($p<0.001$). For averages in 20-year age groups, please see Table 3. Overall measurements decreased by approximately 2.5mm per 20-year age group. As seen in Figure 6, the female population started with an approximately 4mm higher average measurement, and since the male and

female changes in the lateral brow plumb line had similar trajectories over time, the measurement remained higher for females in the oldest age group. This trend did not achieve statistical significance when ethnicity was included in the model ($p=0.12$), but did achieve statistical significance if ethnicity was removed ($p<0.001$).

Ethnicity Analysis: We modeled gender, ethnicity and age together. As seen in Figure 6, there are no statistically significant differences in the rate of plumb line length decrease over time. However, Black males and females appear to have lateral brows that are statistically significantly higher than non-Dominican Hispanics of both genders, female Dominican Hispanics and Caucasian males ($p<0.001$ for all groups); this also approaches statistical significance in comparison to male Dominican Hispanics ($p=0.053$).

Angle from Mid-Brow to Lateral Brow Tail

Grouped Analysis: The average angle narrowed by 0.22° per year ($p<0.001$), denoting a sharper angle at older ages indicating a relative descent of the lateral brow with respect to the central brow with increasing age. For averages in 20-year age groups, please see Table 3. Overall data showed a decline of approximately 3° per 20-year age group. As seen in Figure 7, male angles trended towards a narrower initial angle measurement ($p=0.052$) and a slower rate of angle narrowing ($p=0.055$) than females.

Ethnicity Analysis: We modeled gender, ethnicity and age together. Dominican and non-Dominican Hispanic females had a slower rate of angle narrowing than their peers, whereas Dominican and non-Dominican Hispanic males had a faster rate of angle narrowing than their peers ($p<0.05$ for all).

Discussion

Each of our three key measurements – nasal ala to lateral brow tail, lateral brow plumb line, and angle from mid-brow to lateral brow tail – showed statistically significant decline with age. The nasal ala to lateral brow measurement fell approximately 3mm in each 20-year age group, and neither gender nor ethnicity seems to significantly change its course. The lateral brow plumb line fell by approximately 2.5mm in each 20-year age group; its overall height may be segregated by gender, but ethnicity appears to have a stronger influence. The angle became approximately 3° more acute in each 20-year age group; it may be segregated by gender, but ethnicity appears to have a strong influence in this case as well.

Of note, the difference between male and female measurements of the lateral brow plumb line and angle may relate in part to the widespread prevalence of brow plucking among females. Patients of either gender who plucked their brows were not excluded from this study, as their exclusion would have severely limited subject participation and would not have correlated with the typical patient seen in our practice. However, tattooed or heavily plucked ('pencil') brows were excluded from this study.

The goal of this study was to define the relationship between the lateral brow and age in our clinic population. Despite the number of statistically significant findings that correlate well with our clinical experience and past studies, there was a surprisingly low R^2 range in

complex models involving ethnicity, gender and age for our three key measurements (0.001–0.004%), which was actually better than the R^2 for models of age, age and gender, or age and ethnicity alone. This would suggest that the movement of the lateral brow with age is likely influenced by a multitude of additional factors, in which age, gender and ethnicity play a small but important role. Though our data set was relatively large, we were not able to account for environmental differences, nor were we able to follow subjects over time. Additionally, the lateral brow position is likely influenced by genetic factors that are less homogenous than our subjective designations of ethnicity may account for. Furthermore, this study examined the two-dimensional descent of the lateral brow and did not attempt to take into account the three-dimensional volumetric changes that the soft tissue of the lateral brow and underlying bony structure may undergo with age.

There are a number of other limitations to our study. This study is cross-sectional, so we cannot prove causality for any of the associations that we find between the brow measurements and age, nor use our data to predict rates of descent for a particular individual. This study took place in a resident-run clinic that caters to a largely Dominican population, thus accounting for our disproportionately large number of Dominican Hispanic and female subjects. This skew may have affected our ability to detect smaller differences within other subgroups. Additionally, the patient population is in large part an immigrant population; subjects were likely exposed to a number of different environmental conditions over the course of their lifetimes. Subjects who had prior ocular surgeries – including cataract extraction – were excluded; this limited the number of older patients in our study.

Our study is consistent with a number of other publications. Some of the ethnic differences we have uncovered may help explain some seemingly contradictory findings in the literature.

In our dataset, the overall MRD1 did show a trend towards decline with age, but this did not achieve statistical significance in any group other than Caucasian males. In this measurement, we agreed with a photometric report by van den Bosch *et al.* in which they examined 320 male and female Caucasians and noted a downward trend without statistical significance in MRD1 over age.¹¹ We also agree with Cole *et al.*'s study of 213 subjects, in which MRD1 declined in males and females over time.⁵

In our measurements of the mid-pupil to mid-brow, we noted that the overall slight decline with age did not achieve statistical significance; however, Caucasians were notable for statistically significant lower initial mid-brows compared to their peers, with statistically significant increase in height over time compared to the downward trends of their peers. Differences between ethnicities may explain some of the discrepancies in the literature. Our data agreed with Price *et al.*'s comparative study of 89 African Americans and 75 Caucasians ranging from 20 to 80 years of age, in which a trend towards lower mid-brows was noted in Caucasians when compared to African Americans of either gender.¹² However, our data did not agree with Goldstein and Katowitz's report on 222 male patients between the ages of 10 and 86, of whom 216 were Caucasian, in which they found no change in brow position with age.¹³ In their study, brow position was defined as the distance between the center of the pupil and the inferior brow, as well as the lateral canthus and the inferior

border of the brow.¹³ The trend towards an approximately 3mm difference in height between males and females in our study correlated nicely with that of van den Bosch *et al.*¹¹ Of note, the lateral canthus was not noted to change position over time in their study;¹¹ this finding allowed us to assume lateral canthus stability in our measurements. Our overall trend towards decline in the mid-brow position over age also appears to correlate with the findings of Sclafani and Jung in their study of 30 adult patients' actual and ideal brow positions and shape, as well as the dynamics of brow movement; they found patients older than 40 to have lower brow heights, as defined by the distance between the upper brow border to the orbital rim in a resting position.³

The contradictory findings in our study of the mid-pupil to mid-brow help incorporate the findings of Cole *et al.* into the literature. In their study, no difference in the inferior limbus to mid-brow (ILB) was noted between genders; our differences were not statistically significant. Our data concurs with Cole *et al.*'s finding that increased ILB height was generally found in Black subjects when compared to Caucasians.⁵ Additionally, while their MRD1 declined with age, the ILB height actually increased with age,⁵ which is consistent with our measurements in Caucasians. It is unclear why their study shows increasing ILB height over age, but it is possible that their Caucasian measurements influenced their overall data more than ours did. It is possible that their largely Caucasian population and our smaller Caucasian population were compensating for falling MRD1, and that compensatory raising of the brow was measured despite best efforts to relax the brow when measuring. However, there was no significant correlation in either direction between our MRD1 measurements and our mid-pupil to mid-brow measurements; thus, it would appear that our subjects did likely have relaxed brows when being measured. In Patil *et al.*'s study of 160 Indian female patients, the mid-brow (measured vertically from a reference line through the medial canthi) was also noted to be higher in older age.¹⁴ It would therefore seem that ethnicity may very well have a strong, and at times, discordant, effect on the mid-brow.

In our study, the lateral brow plumb line fell with age, and to a greater degree than the mid-pupil to mid-brow measurement. We therefore agree with Patil *et al.* that preferential elevation of the lateral brow would have a rejuvenating effect.¹⁴ Additionally, Sclafani and Jung's article on 30 adult patients' actual and ideal brow positions and shape noted that the brow tail was significantly higher in women than in men in all dynamic poses;³ the disparity between genders was also noted upon analysis of age and gender in our study, but was not found to be statistically significant in our study once ethnicity was incorporated.

Our measurements show that the angle from the mid-brow to the lateral brow tail becomes approximately 3° more acute in each 20-year age group. Ethnicity appears to play a strong role, in that Dominican and non-Dominican Hispanic females had a slower rate of angle narrowing than their peers, whereas Dominican and non-Dominican Hispanic males had a faster rate of angle narrowing than their peers. A recent study by Prado *et al.* also examined 45 pre- and post-blepharoplasty patients using a series of angles between the medial and lateral canthi and various points along the medial and lateral brow;¹⁵ our angle was not included. While their article focused on the possibility of secondary lateral brow ptosis after blepharoplasty, their discussion regarding the benefit of standardized computerized

measurements to describe and document post-operative changes underscores the benefits of standardized photography and measurements.

In summary, the lateral tail of the brow does descend with age. Measurements of its location and rate of change vary between genders and among ethnic groups. Two easily measured values – that of the nasal ala to the lateral brow tail, and the lateral brow plumb line – can be used for pre-operative planning and post-operative documentation. Neither requires computer analysis. In the absence of prospective data, we hope our study may provide a meaningful, albeit limited, reference for clinicians that can be incorporated into an overall schema of brow movement, measurement and surgical manipulation. Future studies of the brow could benefit from longitudinal measurements based upon this initial exploratory work, as well as correlation between photographic and handheld measurements.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1. Clinical measurements. Mid-pupil to upper lid margin (MRD1) is shown in white; mid-pupil to mid-brow is shown in gray; nasal ala to lateral brow tail is shown in interrupted black; and “lateral brow plumb line,” as defined by the vertical line between the lateral tail of the brow and a horizontal line extending from the lateral canthus, is shown in thick black.

Figure 2.

Angle analysis. Computer analysis of facial photographs allowed for the calculation of the angle formed by the line from mid-pupil to mid-brow and a line from the mid-brow to the lateral brow.

Figure 3.

Gendered averages per 20-year age group of mid-pupil to upper lid margin (MRD1).

Females started off with slightly higher MRD1 in our subjects, but approached a common average of 3.1mm by the oldest age group. Mm refers to millimeter.

Figure 4.

The gendered averages per 20-year age group of mid-pupil to mid-brow in our subjects. Females had a higher central brow by approximately 3mm, which was preserved throughout the age groups. Both males and females have a slight decrease in average measurements over time. Mm refers to millimeter.

Figure 5.

Nasal ala to lateral brow. The graph on the left shows the gendered averages per 20-year age group in our subjects, and demonstrates the relatively similar averages in both genders. The graph on the right shows the similar decline over time in all ethnicities. There was a trend towards a slightly greater decrease in this measurement with time among females compared with males in each ethnic group. Mm refers to millimeter.

Figure 6.

Lateral brow plumb line. The graph on the left shows the gendered averages per 20-year age group in our subjects, which show relatively consistent rates of decline. Females consistently had higher tails of the lateral brow with respect to the lateral canthus than their age-match male counterparts by approximately 4mm. The graph on the right shows a similar clustering of male and female groups, with the exception of Black subjects, who generally had higher measurements than their peers. Mm refers to millimeter.

Figure 7.

Angle from mid-brow to lateral brow tail. The graph on the left shows the gendered averages per 20-year age group in our subjects, and demonstrates the similar measurements in male and female groups. Both groups' measurements decline with age, indicating a descent of the lateral brow with respect to the central brow with increasing age. The graph on the right shows the angle trendline divided into gendered ethnic groups, of which both Hispanic female subgroups had slower rate of angle reduction than their peers, whereas both Hispanic male subgroups had a faster rate than their peers.