



Photogrammetric Analysis of Eyebrow and Upper Eyelid Dimensions in South Indians and Malaysian South Indians

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Abstract

Background: The eyebrow and eyelid are important sexually dimorphic and ethnic features of the face. In cosmetic surgery, maintenance of these landmarks is important to obtaining satisfactory results.

Objectives: The authors quantify the dimension and position of the eyebrow and eyelid in South Indians and Malaysian South Indians and assess whether significant differences exist between the sexes and ethnic groups.

Methods: Evaluation of eyebrow and upper eyelid was performed on standardized photographs of 200 South Indian and 200 Malaysian South Indian subjects, aged 18 to 26 years. We measured eyebrow thickness, apex to lateral limbus distance, apex to lateral canthus distance, interbrow distance, medial end of the eyebrow to medial canthus, lateral end of the eyebrow to lateral canthus, eyebrow height, eyebrow apex inclination, and pretarsal skin height. The measured values were evaluated by an independent *t* test. We also assessed the prevalence of double lid crease and types of epicanthus and eyebrow apex positions.

Results: A significant difference was found between women in the South Indian and Malaysian South Indian groups for eyebrow apex to lateral limbus distance, medial end to medial canthus, pretarsal skin height, eyebrow height, and eyebrow apex inclination. Male groups showed significant ethnic difference for eyebrow apex to lateral limbus distance. Sexual dimorphism was found for all measurement categories. A double crease fold appeared in 99% of the subjects. Only epicanthus tarsalis (95%) and epicanthus superciliaris (5%) appeared in the subjects. Four types of eyebrow apex position were found.

Conclusions: Ethnic and sex differences exist for eyebrow and eyelid dimensions in the 2 groups we studied. Knowledge of these trends is significant during surgical planning to obtain ideal outcomes.

Keywords

sexual dimorphism, eyebrow, eyelid, anthropometry, facial attractiveness, oculoplastics

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The eyebrow and upper eyelid are the most important landmarks of the upper face; they have a marked impact on facial attractiveness, emotional expression, and identification of ethnicity and sex. Aging causes laxity in the skin and soft tissues of the periorbital region and descent from long-term effects of gravity. The resultant ptosis affects the position of the periorbital features, which in turn alters the emotional expression and natural appearance of the face. Youthful rejuvenation of the upper face with procedures such as blepharoplasty, double eyelid surgery, and browlifting can yield unsatisfactory results because of variations in the morphology and anatomical relationship of periorbital features among different ethnic

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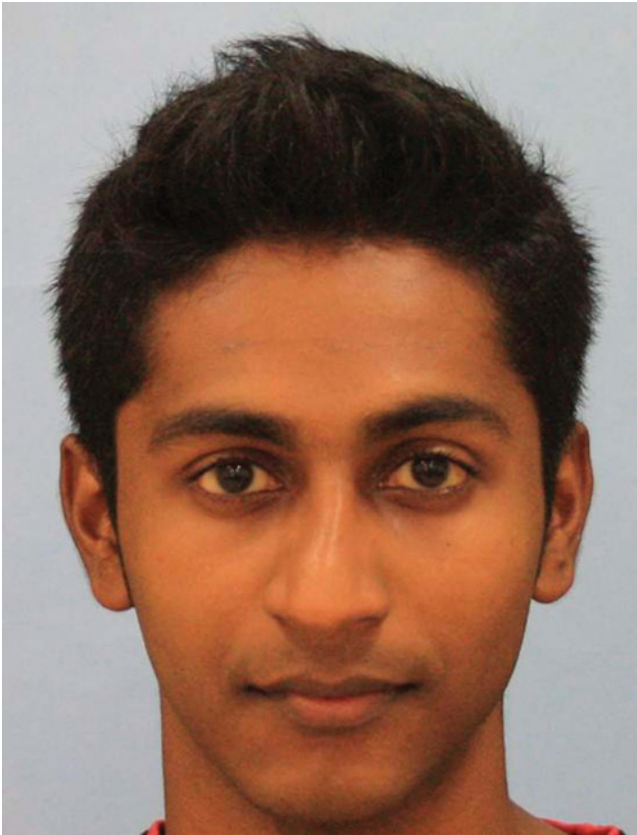


Figure 1. Representative photograph of a 20-year-old South Indian man.



Figure 2. Representative photograph of a 23-year-old South Indian woman.

groups. Kunjur et al¹ suggested that applying the aesthetic standards of a particular group may not suit other patients of diverse racial and ethnic backgrounds. Therefore, in recent years, anthropometric studies on periorbital features have been conducted in different racial/ethnic groups to establish a normative database.¹⁻⁷

Recent surveys state that the improved socioeconomic status and changing fashion trends in the Indian population have triggered the demand and desire for cosmetic surgery, which is now easily available and affordable. Simultaneously, the competence and number of cosmetic surgeons have also increased.⁸ However, to date, there are no data regarding ideal periorbital morphology available in the literature specifically for South Indians from India and Malaysian South Indians. Since these 2 groups are Dravidian people (non-Aryan races of Southeast Asia who are distributed mainly in South India, Sri Lanka, Malaysia, Singapore, Bangladesh, and Nepal), the anthropometric norms of other races and ethnic group may not fit these patients. The aim of this study was to quantify the dimension and positions of the eyebrow and eyelid in South Indian (SI) and Malaysian South Indian (MSI) populations. A secondary aim was to determine whether

any significant variation exists between the sexes within these groups.

METHODS

This study was approved by the Manipal University ethics committee (UEC/58/2010). Informed written consent was obtained from all participants prior to beginning the study. A total of 400 Dravidian subjects (200 SI and 200 MSI) (Figures 1-4) aged between 18 and 26 years were selected randomly from the staff and student population at Manipal University. The photographic system consisted of a Canon EOS 1000 D SLR camera (Canon USA, Inc, Melville, New York) with a built-in grid feature. The camera was mounted on a tripod to provide stability and correct the height of the camera according to each subject's body height. The grid feature was used to align the camera to the subject's eyes and to avoid the head being tilted to either side. The camera and tripod were leveled precisely by using a triple axis bubble level.

Subjects were positioned against a blue background at a standardized distance of 51 inches from the camera, with the head in Frankfort's horizontal position and the



Figure 3. Representative photograph of a 21-year-old Malaysian South Indian man.



Figure 4. Representative photograph of a 21-year-old Malaysian South Indian woman.

eyes open in primary gaze. A millimeter scale was framed in the vertical plane along the side of the subject to perform the measurement at “life size,” after which a frontal image of each subject’s face was captured using a 105-mm lens. Eyebrow and eyelid measurements (Figures 5 and 6) were done independently on the digital images by 2 examiners (V.P. and P.K.) with the ImageJ analyzer (ImageJ 1.43; National Institutes of Health, Bethesda, Maryland). These measurements included eyebrow thickness, apex to lateral limbus (A-LL) distance, apex to lateral canthus (A-LC) distance, interbrow distance (IB), distance from the medial end of the eyebrow to medial canthus (ME-MC), distance from the lateral end of the eyebrow to LC (LE-LC), eyebrow height, eyebrow apex inclination, and pretarsal skin height. When the brow apex was medial to the lateral canthus (LC) or lateral limbus (LL), a positive value was given; if the apex was lateral to either the LC or LL, a negative value was given. We also evaluated the incidence of double fold, types of epicanthus, and eyebrow apex position. Statistical analysis was performed using SPSS Windows version 14.0 software (SPSS, Inc, an IBM Company, Chicago, Illinois). The outcome variables were calculated as mean and standard deviation. The prevalence of a double lid crease, types of epicanthus, and eyebrow apex positions were calculated as percentages of the subject population. An

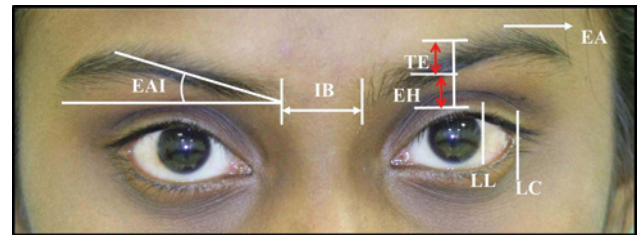


Figure 5. Eyebrow measurements included the thickness of the brow, the horizontal distance from the apex to the lateral limbus (A-LL) and to the lateral canthus (A-LC); IB, interbrow distance (ME-ME); EAI, eyebrow apex inclination (angle formed, between the horizontal reference line and line drawn through the inferomedial portion of the eyebrow, to the eyebrow apex); and EH, eyebrow height (from the middle of the open upper lid margin to the lower margin of the eyebrow). EA, apex of the eyebrow; LC, line drawn perpendicular to the lateral canthus; LL, line drawn perpendicular to the lateral limbus (outer aspect of the sclera); ME, medial end of the eyebrow; TE, thickness of the brow.

independent *t* test was done to test the differences between sexes and between ethnic groups. Values of *P* < .05 were considered significant.

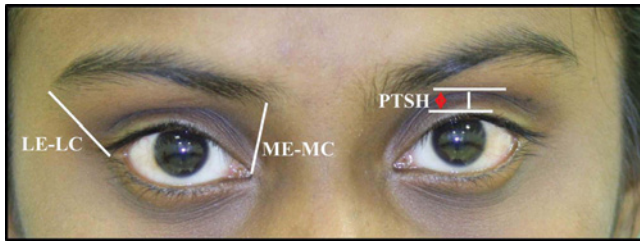


Figure 6. Open upper eyelid measurements. LE-LC, distance from the lateral end of the brow to the lateral canthus of the eye; ME-MC, distance from the medial end of the eyebrow to the medial canthus; PTSH, pretarsal skin height (from the superior lid margin to the visible upper lid crease or skin fold over the pupil).

Table 1. Comparison of Measurements (mm) in Men

Anthropometric Measure	Malaysian South Indians (n = 100), Mean (SD)	South Indians (n = 100), Mean (SD)	P Value
TE	8.17 (1.80)	7.85 (1.72)	.201
A-LL	-7.71 (3.03)	-6.50 (2.85)	.004 ^a
A-LC	0.43 (3.12)	0.87 (3.24)	.334
IB	24.02 (5.25)	24.40 (6.04)	.635
EAI	6.8 (3.68)	6.6 (3.60)	.761
EH	5.43 (2.87)	5.19(2.12)	.496
ME-MC	13.54 (2.49)	13.13 (2.52)	.249
LE-LC	16.25 (2.39)	16.09 (2.29)	.638
PTSH	2.38 (1.63)	2.24 (1.51)	.573

Abbreviations: A-LL, apex to lateral limbus distance; A-LC, apex to lateral canthus distance; EAI, eyebrow apex inclination; EH, eyebrow height; IB, interbrow distance; LE-LC, lateral end of the brow to lateral canthus; ME-MC, medial end of the brow to medial canthus; PTSH, pretarsal skin height; TE, thickness of eyebrow.

^aStatistically significant difference.

RESULTS

Comparisons Between Ethnic Groups

Eyelid measurements

In men, eyebrow height, pretarsal skin height, ME-MC distance, and LE-LC distance were greater in MSI than in SI subjects, but the difference was not statistically significant (Table 1). In women, eyebrow height ($P < .001$), pretarsal skin height ($P = .04$), and ME-MC distance ($P = .032$) were statistically significantly greater in MSI than in SI subjects. In contrast, the LE-LC distance was insignificantly greater in SI women than in MSI women (Table 2).

Eyebrow measurements

In both men and women (Tables 1 and 2), eyebrow thickness and IB distance were greater in MSI than in SI

Table 2. Comparison of Measurements (mm) in Women

Anthropometric Measure	Malaysian South Indians (n = 100), Mean (SD)	South Indians (n = 100), Mean (SD)	P Value
TE	6.57 (1.36)	6.37 (1.30)	.29
A-LL	-6.76(2.07)	-5.51 (2.31)	<.001 ^a
A-LC	1.165 (2.42)	1.733 (2.11)	.079
IB	22.21 (5.80)	20.92 (5.33)	.101
EAI	11.1 (3.1)	10.06 (3.9)	.038 ^a
EH	9.207 (2.62)	7.924(2.0)	<.001 ^a
ME-MC	16.56 (2.30)	15.81 (2.60)	.032 ^a
LE-LC	17.15 (2.08)	17.58 (2.50)	.195
PTSH	3.33 (1.63)	2.91 (1.22)	.04 ^a

Abbreviations: A-LL, apex to lateral limbus distance; A-LC, apex to lateral canthus distance; EAI, eyebrow apex inclination; EH, eyebrow height; IB, interbrow distance; LE-LC, lateral end of the brow to lateral canthus; ME-MC, medial end of the brow to medial canthus; PTSH, pretarsal skin height; TE, thickness of eyebrow.

^aStatistically significant difference.

Table 3. Incidence and Type of Epicanthus

Type of Epicanthus	Male (n = 200)	Female (n = 200)	Total, No. (%)
Epicanthus tarsalis	189	191	380 (95)
Epicanthus superciliaris	11	9	20 (5)
Epicanthus palpebralis	0	0	0
Epicanthus inversus	0	0	0

subjects, but the difference was not statistically significant. Both sexes of MSI subjects had eyebrow apexes that fell significantly more lateral to the LL than the SI subjects (male, $P = .004$; female, $P < .001$). Similarly, eyebrow apex inclination was significantly greater in MSI women than in SI women, while the A-LC distance was insignificantly more medial to the lateral canthus in SI than in MSI subjects, both in male and female groups.

Comparisons Between Sexes

We found significant differences in all measurements in both ethnic groups when the results were assessed by sex.

Eyelid measurements

The eyebrow height (in both ethnic groups, $P < .001$), pretarsal skin height (SI, $P = .008$; MSI, $P = .003$), ME-MC distance (in both ethnic groups, $P < .001$), and LE-LC distance (SI, $P < .001$; MSI, $P = .005$) were significantly larger in women than in men.

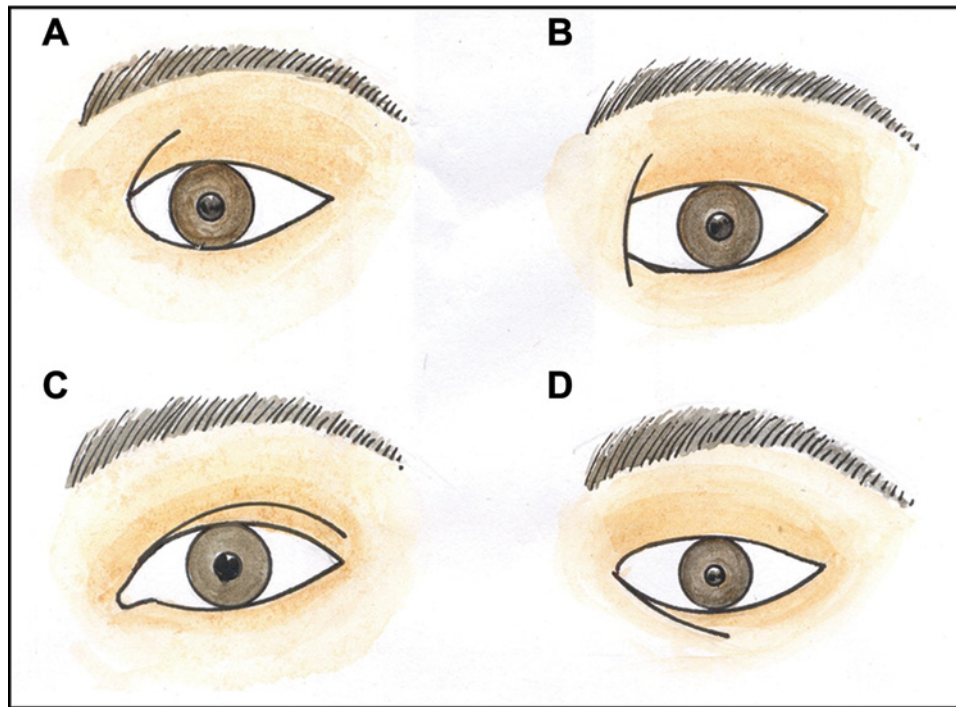


Figure 7. Types of epicanthus based on Johnson's classification. (A) Epicanthus superciliaris, (B) epicanthus palpebralis, (C) epicanthus tarsalis, and (D) epicanthus inversus.

Table 4. Types of Eyebrow Apex Position in South Indians (SI) and Malaysian South Indians (MSI)

Eyebrow Apex Position	Male		Female		Total, No. (%)
	SI	MSI	SI	MSI	
LL	1	2	2	2	7 (1.75)
HF	55	48	83	69	255 (63.75)
LC	4	2	7	1	14 (3.5)
LM	40	48	7	29	124 (31.0)

Abbreviations: HF, halfway between the lateral limbus and lateral canthus; LC, above the lateral canthus; LL, above the lateral limbus; LM, lateralmost brow.

Eyebrow measurements

The eyebrow thickness (in both ethnic groups, $P < .001$), IB distance (SI, $P < .001$; MSI, $P = .0216$), and eyebrow apex inclination (in both ethnic groups, $P < .001$) were significantly greater in men than in women. Eyebrow A-LL position was significantly more lateral in men than in women (SI, $P = .078$; MSI, $P = .011$). In contrast, eyebrow A-LC position was significantly more medial in women than in men (SI, $P = .026$; MSI, $P = .065$).

Type of epicanthus

Epicanthus tarsalis was found in 95% of the subjects (189 men; 191 women). Epicanthus superciliaris was found in 5% (11 men; 9 women). Epicanthus palpebralis and inversus were not found in any subjects (Table 3; Figure 7).

Types of eyebrow apex positions

The eyebrow apex was found at 4 positions: 1.75% of the subjects (3 men, 4 women) had the apex at the LL, 63.75% (103 men, 152 women) had it between the LC and LL, 3.5% (6 men, 8 women) had it at the LC, and 31% (88 men, 36 women) had the apex in the LM position (Table 4; Figure 8).

DISCUSSION

Recent investigators have emphasized that knowledge of featural cues (sexually dimorphic and ethnic features) of the periorbital region are very important⁹⁻¹¹ to obtaining ideal surgical outcomes.^{1,2} Therefore, determining the anthropometry of the eyebrow and eyelid by sex and ethnicity is required. At present, there are a few published studies of eyebrow and eyelid measurements in Indians,^{1,4} but due to certain factors (interethnic variation, variable age, and sample composition), these study databases may not specifically represent the SI and MSI, who are Dravidian

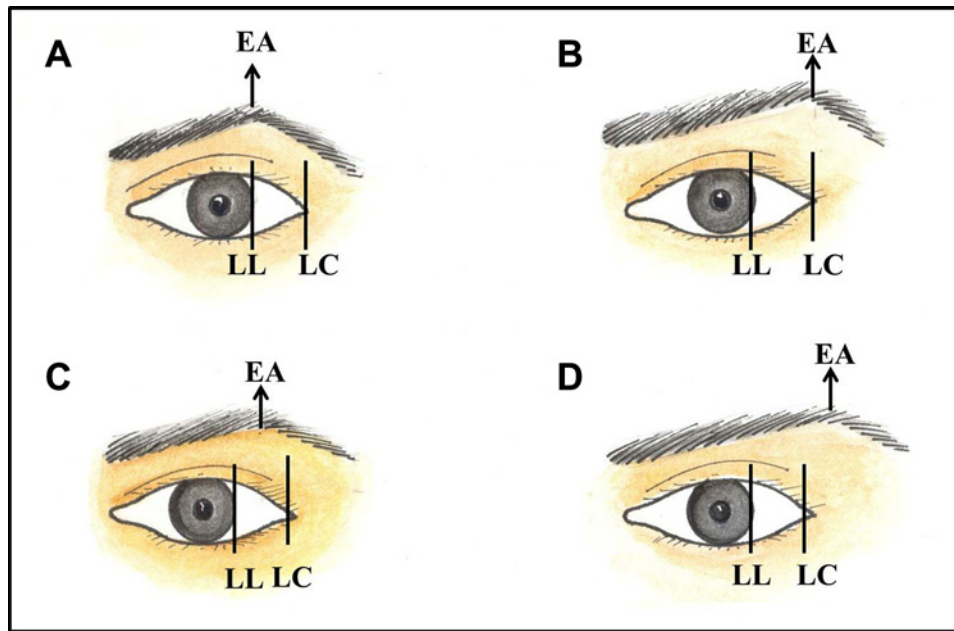


Figure 8. Types of eyebrow apex position. (A) Above the lateral limbus, (B) halfway between the lateral limbus and lateral canthus, (C) above the lateral canthus, and (D) lateralmost brow. EA, apex of the eyebrow; LC, lateral canthus; LL, lateral limbus.

people. This lack of literature reveals the need to establish ethnicity-specific normative values. Recent photogrammetric studies have found that the eyebrow apex is more lateral to LL in men than in women,^{1,2,12} suggesting that LL and LC position is not always an accurate predictor of eyebrow apex. In contrast, Kunjur et al¹ found that the apex was more lateral in Chinese women. Those authors found that, on average, the eyebrow apex position fell between the LL and the LC in white and Chinese patients, but not in Indian patients, in whom it was lateral to the LC. The ideal eyebrow apex position (between the LL and the LC) of SI and MSI subjects in our study group varies, which may be due to composition of the study population. Also, the interethnic difference could have played a role.

Campbell et al¹³ showed how changes in facial animation that affect brow position can alter perception of the sex. Bashour⁹ stated that eyebrows are the most important features of the face for sexual dimorphism and facial recognition. The values of the measured parameters are in line with the fact that eyebrow apex is steeper, more inclined, and more lateral to the LL in MSI women than in SI women, which makes it an ethnic feature. The fact that it is again steeper and more inclined but more medial (to the LC) in women than in men also makes it a sexually dimorphic feature.

Several other researchers¹⁴⁻¹⁷ have used digitally modified photographs of the female face to study the perceptions and preferences for eyebrow aesthetics for a specific cohort. Freund and Nolan¹⁴ found that plastic surgeons and cosmetologists preferred the arch lateral to the LL. In a similar study, Gunter and Antrobus¹⁵ found that plastic surgeons preferred the apex between the LL and the LC.

Biller and Kim¹⁶ found that physicians, nurses, students, and members of the general public preferred the peak above the LL and mid pupil (MP) in older whites and Asian models. In young models, the face was deemed most attractive when the eyebrow apex was above the LL (whites) and between the LL and LC (Asians). In another study on female magazine models, Roth and Metzinger¹⁷ quantified the eyebrow apex in relation to eye width. They found that the eyebrow apex fell between 93% and 98% of the eye width in young women and 87% of the eye width in older subjects. As suggested by Freund and Nolan,¹⁴ it is evident from our study that the ideal aesthetic brow is not entirely subjective; eyebrow apex data from our study (lateral to the LL and, on average, between the LL and LC) are in agreement with the other studies in which volunteers of different professions and ethnicities preferred the eyebrow apex position more lateral to the LL and between the LL and LC in younger and attractive faces.¹⁴⁻¹⁷ However, some of our subjects' measurements differed from the ideal aesthetic brow position, which may be due to greater intercanthal distance¹⁸ and different facial shape.¹⁹ It is important to consider these factors and the patient's preferences when performing browlifts. Preoperative assessment can be accomplished by taping the eyebrow in the desired position(s) or by the use of digital image manipulation and morphing programs. This can approximate the preferences (of patient and surgeon) and surgical outcomes.

The thickness of the eyebrow and IB distance were the 2 sexually dimorphic parameters that were significantly greater in men than in women, with no significant interethnic differences. Bruce et al²⁰ found that the thickness of the

eyebrow plays an important identifying role for male and female faces. Men with thick and flat eyebrows are linked to the perception of dominance, as brow thickness is considered one of the powerful sexually dimorphic facial features.²¹ Women with thin and raised eyebrows are considered more attractive.²² Some of the male subjects had thick, bushy eyebrows and protruding supraorbital ridges (frontal bossing), which created an illusion of deep-set eyes. The IB distance was significantly wider in men than in women with a higher standard deviation. In contrast, Anthony and Jung²³ found that the IB distance was wider in women than in men, again with a higher SD. The IB distance showed a higher SD, perhaps due to variation in the position of the medial end of the eyebrow.

The periorbital area is aesthetically significant, since Dravidian women (specifically married women) use this area to enhance beauty and femininity by placing a traditional cosmetic enhancement called *pottu* (a round red spot). A round red spot analysis was done with 2 images of a woman (Figure 9; available as an online-only appendix at www.aestheticsurgeryjournal.com). The woman was photographed with (Figure 9A) and without (Figure 9B) the round red spot in her interbrow area. The 2 photographs were subsequently rated randomly by 417 volunteers (members of the general public) aged 16 to 60 years. The vast majority (97.5%) of the general public preferred Figure 9A. A small percentage (1.75%) of the volunteers preferred both images. The remaining 0.25% of the volunteers preferred Figure 9B. We can therefore infer that placing the round red spot in the interbrow area produced an aesthetically pleasing appearance.

In our study, eyebrow height, pretarsal skin height, and ME-MC and LE-LC distance were greater in MSI than in SI subjects at a statistically significant level, with the exception of the LE-LC measurement. Sexual dimorphism is clinically significant because eyebrow height and pretarsal skin height are generally known to be greater in women and are powerful features in increasing female facial attractiveness. In contrast to general clinical trends, Kunjur et al¹ and Patil et al⁴ reported greater eyebrow height for men than for women in Chinese and Indian patients. Park et al³ found larger values for both sexes in Asian patients (male, 12.3 mm; female, 12.5 mm) and more equal values in Koreans⁷ (male, 10.3 mm; female, 10 mm). Price et al² found that pretarsal skin height of black men was as high as that in black and white women. Lemke and Stasior²⁴ described, anatomically, the reasons why patients' lateral eyebrows may be more ptotic than the medial end by specifying that the circumorbital muscles (frontalis and orbicularis oculi) at the lateral eyebrow are less adhered to the skull.

Some authors have stressed the importance of lateral brow correction rather than the medial brow. Prado et al²⁵ showed that upper eyelid blepharoplasty can also accentuate the tendency of the eyebrow (lateral end) to move down. Tapia et al²⁶ found that lifting the medial, central, and lateral portions of the eyebrow produces an overall satisfactory result. However, the clinician should have a knowledge of the local trends and ethnic norms when deciding how much to elevate the brow for facial rejuvenation,

because in certain circumstances, overelevation has the side effect of producing an illusion of smaller eyes and a more feminine look (in men).

A double fold, which is a crease formed by attachment of the levator palpebral superioris to the pretarsal orbicularis and skin, was found in all our subjects, as it is in whites. Park et al³ found it in only 30.5% of men and 41.4% of women. We found a triple fold in 3.5% of subjects (0.1% of men and 2.5% of women), whereas Park et al³ found it in 0.6% of subjects in both sexes. Regarding the type of epicanthus, in both sexes, epicanthus tarsalis was found in 95% of our subjects, and epicanthus supercilairis was found in only 5% of our subjects. Epicanthus palpebralis and inversus did not appear in any subject. Park et al³ noted 4 types of epicanthus in Asians; epicanthus tarsalis was found most frequently, in 50.5% of the subjects. Epicanthus inversus appeared the least, in 5% of the subjects.

In our study, the morphology of the periorbital region was studied by using indirect anthropometry (photogrammetry technique and software). Coombes et al²⁷ suggested that digital photography combined with computer analysis offers an advantage over direct anthropometry; the method is simple, standardized, and documentable, and it can be applied in the research. Price et al² used indirect photogrammetry for measurement of eyebrows and eyelids, as we did. They found that the results obtained from indirect photogrammetry are as reliable as direct caliper measurement.

CONCLUSIONS

On the basis of our measurement results, we can conclude that the dimension and position of eyebrows and eyelids are entirely different between men and women of both South Indian and Malaysian South Indian descent, but statistically significant differences were noted only in certain measurements between the 2 ethnic groups, particularly among women in each group. Since these measurements may affect surgical planning, it is important to consider sex- and ethnic-specific normative values to obtain a satisfactory result.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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