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The Latino eyelid: anthropometric analysis of a spectrum of findings

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Abstract

Purpose—Published anthropometric measurements of the Latino eyelid are limited. This study describes features spanning the morphological range from non-Latino Caucasians to East Asians in the spectrum of the Latino eyelid.

Methods—A cross-sectional study of 68 people (32 Latinos, 18 non-Latino Caucasians and 18 East Asians, ages 18–39), approved by the Institutional Review Board and HIPPA-compliant, was performed. Saliva samples determined genetic components. Indirect anthropometric measurements were performed with *ImageJ* software. Eyelid measurements included: margin reflex distance, palpebral fissure height, eyelid crease height, orbital height, horizontal fissure length, inner and outer canthal distances, medial and lateral canthal angles and lateral canthal angle of inclination. Additionally, exophthalmometry and epicanthal folds were recorded.

Results—Analysis of 184 markers from HumanExome Chip data revealed distinct clustering patterns. Genetically, the Asian participants were in one group, the Caucasians in another group and the Latinos spanned the spectrum between these two groups.

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In Latinos, the inner canthal distance and lateral canthal angle of inclination were similar to Asians, while the lid crease spanned the range from Asians to Caucasians. Half of the Latinos had epicanthal folds.

Conclusions—Latinos possess a spectrum of eyelid features spanning the morphologic characteristics from those of non-Latino Caucasians to those of East Asians. This normative data on Latinos from Texas and Mexico aids in the diagnoses of Latino eyelid disorders and is a reference for optimizing oculofacial surgery outcomes.

The Latino population is responsible for more than half of the United States' population growth in the decade preceding the 2010 Census, with Latinos/Hispanics comprising over 16% of the total population.¹ In San Antonio, Latinos/Hispanics comprise 63% of the population.² However, there are only three studies addressing periocular measurements in Latinos.^{3–5} Thus, while the normal eyelid anatomy of Caucasians and Asians has been well-delineated, there is a paucity of data regarding Latino eyelid characteristics.^{6–9}

We have noted a wide variation in Latino eyelids with some Latinos having classic European features, and others having certain characteristics typically associated with East Asian heritage, such as epicanthal folds. As a result, we found ourselves modifying surgical approaches in Latinos with Asian like characteristics. Understanding this variation is important to providing patients of Latino/Hispanic heritage with optimal outcomes in oculofacial surgery. In order to better understand the features we were noticing, we undertook a prospective trial to analyze and describe the spectrum of the Latino eyelid and compare it to non-Latino Caucasians and Asians.

Methods

The study was approved by the Institutional Review Board at The University of Texas Health Science Center, San Antonio. Participants signed informed consent, which has been archived, and the study is compliant with the Health Information Portability and Accountability Act of 1996 (HIPAA).

Demographics

A total of 68 healthy Latino, Asian and Caucasian male and female volunteers, ages 18–39, were enrolled in the study. The term Latino is used to describe people who report themselves as Latino, Mexican, Mexican-American, South American or Caribbean. Participants were recruited from the employees, staff, patients and family members of The University of Texas Health Science Center, San Antonio and the University's "Find a Study" website. Participants identified their race and ethnicity. Exclusion criteria were: eye disease or trauma, eyelid or intraocular surgery and pregnancy. None of the Latinos or Caucasians had ever worn contact lenses, but the Asian community in San Antonio is small; thus contact lens wearers were included so there would be a sufficient number of subjects.

Genotyping and Marker Selection

Saliva specimens were collected from 48 of the participants. Genomic DNA was isolated from 500 µl of saliva with an Oragene prepIT-LP2 kit (DNA Genotek, Kanata, Ontario,

Canada). Briefly, DNA pellets were resuspended in 100 μ l of Tris-EDTA buffer. DNA quality and quantity were determined using agarose gels and a NanoDrop 1000 spectrophotometer (ThermoScientific, Wilmington, DE). Genomic DNA (200 ng) was whole-genome amplified, enzymatically fragmented and hybridized to BeadChips (Illumina HumanExome v1.2 BeadChips, San Diego, CA). This was followed by a single-base extension with fluorescently labeled nucleotides. All steps were performed on a Tecan Freedom EVO 150 cm liquid handler (Tecan, Männedorf, Switzerland) with *Illumina GTS Robot Control* software (Illumina). Fluorescence intensities were detected using the Illumina iScan and analyzed in *GenomeStudio* (Illumina); accuracy was ensured with sample-dependent and -independent controls.

A total of 204 markers were selected from HumanExome BeadChip data, based on the following criteria: call frequency > 1.00 , minor allele frequency (MAF) > 0.35 in Caucasians and < 0.05 in Asians, or an MAF < 0.05 in Caucasians and > 0.35 in Asians. There was strong linkage disequilibrium (LD) in 20 markers, therefore they were removed from the study and the remaining 184 markers were analyzed.

A principal component analysis (PCA) was applied to the genotype data using both *PLINK* (version 1.9) and *EIGENSOFT* (version 5.0.2) software to reduce the data into a small number of dimensions (principle components, PCs) describing as much variability as possible. The most relevant PCs were compared. Self-reported ethnicity was compared to PCA.

Digital Images and Measurements

Digital images were acquired utilizing a Nikon D3000 digital camera with the object-lens distance at 120 cm with the participant's head positioned such that the top of the tragus was in alignment with the infraorbital rim (the Frankfurt horizontal plane) with a ruler affixed to the face. Digital image analysis (DIA) was performed using *ImageJ* (*ImageJ*, U. S. National Institutes of Health, Bethesda, Maryland, USA, <http://imagej.nih.gov/ij>) software. For each image, *ImageJ* was used to convert a set distance in millimeters (as calibrated with the ruler) to pixels/millimeter; the pixels/millimeter ratio measured the distance between given points.

Digital measurements obtained were: margin light reflex distance (MRD1); palpebral fissure height (PFH); eyelid crease height (CR); horizontal fissure length (HFL); inner canthal distance (IC); outer canthal distance (OC); and orbital height (OH) (Fig. 1a). The CR was measured in downgaze and the brows were raised gently if there was a redundancy of the skin, in order to allow measurement of the full extent of the skin from the margin to the CR. The edge of the orbital rim in the upper and lower eyelids was marked by a small piece of tape and the OH was measured by drawing a vertical line through the center of the pupillary light reflex. Additionally, DIA was used to calculate the following: medial and lateral canthal angles (MCA, LCA), angle of inclination of the lateral canthus relative to a reference line drawn horizontally from the medial canthus (LCInc), and the distance in millimeters to the reference line (LCDist) (Fig. 1b). Direct manual measurements of MRD1 and IC were taken to ensure accuracy of the DIA.

Additionally, the presence of epicanthal fold and exophthalmometry, using both Naugle and Hertel exophthalmometers, were recorded.

Statistical Analyses

The features of the three ethnicities were compared using ANOVA with gender adjustment. Men and women were compared as a collective group and in each ethnic group using an independent 2-group t-test. The Mann-Whitney U test determined if contact lens wear affected the data from the Asian population. Bland Altman plots assessed the comparability of the DIA and manual measurements.

Results

Of the 68 subjects (136 eyes), 36 were women (average age 28 yrs) and 32 were men (average age 31 yrs). The subjects self-reported their ethnicity to be: 32 Latinos (16 Mexican-Americans, nine Mexicans, four Latinos, two Caribbeans, and one South American; 17 men, 15 women), 18 Caucasians (ten men, eight women), and 18 East Asians (nine Chinese, seven Vietnamese, one Japanese, and one Korean; seven men, 11 women). Two of the 32 Latinos had mixed ethnicity (Latino and Asian). Of the 18 Asians, three wore contact lenses.

Genetic analysis, as per PCA, indicated that the first two principal components, PC1 and PC2, capture most of the variation in the study. On plotting PC1 versus PC2, clustering patterns emerged with Asians clustered in the lower left, European Caucasians to the right, and Latinos in the center (Fig. 2). The two Latinos of mixed ancestry were in the middle of the PC1/PC2 plot. Genetic analysis was performed on 100% of Latinos (N=32), 72% of Caucasians (N=13) and three of the East Asians. Self-reported ethnicity was consistent with PCA data.

Of the thirteen features measured, three were significantly different between the ethnic groups (Table). In the Latinos, IC distance and the LCInc and LCDist measured between that of Asians and Caucasians (Figs. 3a,b). Additionally, an epicanthal fold was present in 50% (n=32 eyelids) of the Latinos, 94% (n=34 eyelids) of Asians and none of the Caucasians. In patients with epicanthal folds, the medial CR inserted at the medial canthal tendon in all Asians and 81% (n=26 eyelids) of Latinos; in three Latinos the CR extended below the tendon. All Asians and 79% (n=25 eyelids) of Latinos had an epicanthal fold originating from the tarsal fold; in 21% (n=7 eyelids) of Latinos the fold originated below the tarsal fold.

The MRD1 was similar amongst Latinos and Asians. The CR of Latinos spanned the range from Asian to Caucasian (Fig. 3c). In the two patients of mixed Latino-Asian ancestry, all of the measurements were in the mid-range of the Latino population, except one subject had a more acute LCInc. The Latinos and Caucasians were similar to each other and statistically different from the Asians in the following: HFL, OH and MCA. The Mann-Whitney U test showed that contact lens wear did not affect the measurements in Asians.

The gender differences between the three ethnic groups revealed the MRD1 and CR was larger in women than in men and the IC and OC were smaller, but only the MRD1, IC, and OC met statistical significance in the Latinos. In the Asians, only the MRD1 and OC met statistical significance between genders. In the Caucasians, none reached statistical significance. The position of the lateral canthus was only significantly different between the genders in Caucasians.

The validity of the data was confirmed by comparing digital and manual measurements of MRD1 and IC. There was no statistical difference.

Discussion

Anthropometric measurements establish normative data for specific patient populations. The understanding of periocular features, especially the differences between Caucasian and Asian features, has been critical to modifying surgical approaches thereby improving aesthetic and reconstructive surgery. This study is the first to describe a spectrum of eyelid manifestations in the Latino population. The Latino eyelid in peoples from Texas and Mexico encompasses a range of morphologic characteristics, from classic findings of the non-Latino Caucasian eyelid to some features similar to Asians, such as a wider IC, acute LCInc and epicanthal folds (Fig. 4). These eyelid features are not the same as the Asian eyelid, but rather are their own unique subgroup.

Self-reported ethnicity was consistent with genetic analysis using PCA. The features reaching statistical significance between the groups were the same when analyzed using either self-reported ethnicity or PCA. Genetic analysis confirmed that Latinos have a range of genetic findings that lie between that of the Caucasians and Asians.

On comparing our data with that published elsewhere, we were able to confirm the validity of our DIA technique as the Asians and Caucasians had comparable measurements of IC, OC and HFL to those reported in a large international anthropometric study.⁷

Comparing Anthropometric Measurements

This study demonstrates a spectrum of presentations of the Latino eyelid, with some eyelids mirroring non-Latino Caucasian features and others having some features similar to the Asian eyelid (Fig. 4). Eyelid features of Latinos that are similar to Asians included: IC, LCInc and LCDist. Moreover, the CR of Latinos was between that of Asians and Caucasians. The full range of the Latino eyelid features spanning the spectrum from the Caucasians to the Asians is best depicted in the boxplots (Figs. 3a–c). Additionally, half of the Latinos were found to have epicanthal folds, a feature of East Asians.

The IC was highly statistically different between the three groups with distances for Latinos between those of Asians and Caucasians. There is little data regarding Latinos, but there are two prior studies comparing the midface features of Latinos or Hispanics to Asians. One study found Hispanics having wider faces and interpupillary distances while another found Latino females to have nose configurations that ranged in appearance from Caucasian to Asian to African depending on their country of origin.^{4,5} This is consistent with our finding

of other Asian type features, e.g. a wider IC, a lower CR, a greater LCInc and the presence of epicanthal folds in many of our subjects.

The statistically significant difference in the LCInc amongst the three groups highlights the range of the Latino eyelid and is one of the more important findings. The distance and the angle of inclination between the lateral canthus and the reference line drawn at the medial canthus was largest in the Asians (8.0 degrees), intermediate in the Latinos (6.0 degrees), and smallest in the Caucasians (2.5 degrees). As noted previously, the lateral canthus is 2.0 mm or 4.0 degrees higher than the medial canthus in Caucasians, compared to 3.0–5.0 mm and 6.0–9.0 degrees higher in Asians, and 9.0 degrees higher in Brazilian Indians.^{6, 10–13}

In Latinos, the CR averaged 6.8 mm, which was between that of Asians and Caucasians. The average CR for Latinos and that of Caucasians (7.7 mm) was lower than the stated normal CR¹⁴ of 8 mm for men and 10 mm for women. However, a prior study on Caucasians found similar CR measurements to ours, with an average CR of 6.9 mm for men and 7.3 mm for women ages 21–40.¹⁵ Most Asians (94%) in our study had a CR; three had a low CR and 14 had a double eyelid. After excluding the patients with the single lid and low CR, the average CR for Asians was 5.6 mm, which was somewhat lower than Latinos and significantly lower than the Caucasians, yet comparable to that in the literature.^{11,16,17}

Epicanthal Folds in the Latino Population

A unique finding of our study was the presence of an epicanthal fold in 50% of the Latino population that has not been previously reported. Epicanthal folds in normal adults are typically attributed to Asian heritage and are rare in Caucasians.¹⁸

The typical epicanthal fold in Asians is epicanthus tarsalis, originating at the tarsal fold and covering the medial upper lid lashes. Approximately 40–90% of Chinese have epicanthus tarsalis depending on their region of origin.^{16,19} However, although 79% of Latinos with epicanthus had it originating from the tarsal fold, none had epicanthus covering the medial lid margin; in 21% the epicanthus originated below the tarsal fold. Epicanthus has been described in some Native Americans, with a version of epicanthus tarsalis, like that seen in our Latino population, occurring in 30% of the adult Angmagssalik Eskimos; thus demonstrating a similarity between Native Americans and the Latinos in our study. However, the majority of Eskimos (58%) have an epicanthal fold originating below the tarsal fold, as was seen in 21% of the Latinos with epicanthus in this study.²⁰

While there is relatively little data about Native American eyelid features, the similarities to some of our Latino patients' are important. In San Antonio, the Southwestern United States and Mexico, genetic analysis has found an 18–65% incidence of Native American ancestry in the Mexican American population.^{21–23} Thus, the East Asian features seen in many Latino eyelids may well be related to the Native American admixture in the population.

Study Limitations

Limitations of the study include DIA of the LCInc, CR, OH, as well as measurements by exophthalmometry. DIA of the periorbital structures has been validated by other authors.²⁴ In order to minimize error from DIA, a standard head position was selected, the Frankfurt

horizontal plane. However, attempting to measure the lateral canthal angle, which is a three-dimensional structure, with two-dimensional photos introduces a source of error that has yet to be fully analyzed in the literature. Ideally three-dimensional photogrammetry would be the best way to perform these measurements but was not available for this study.

In order to measure the maximum height of the CR, the brows were gently elevated as described by others previously.¹⁵ Thus, it is possible the CR measured may be higher than it would have been if measured by other methods. Additionally, measuring the orbital height utilizing surface landmarks, while utilized by other authors, is not ideal.⁶ The OH measurements obtained should be validated with direct measurements of bony landmarks on neuroimaging or by using cadavers. Finally, exophthalmometry was performed to confirm that none of the participants had either enophthalmos or exophthalmos that might skew the eyelid measurements. The exophthalmometry measurements were taken by one examiner. A formal study, with multiple readings and examiners, should be undertaken to optimize results and standardize normative data in this population.

Another limitation of the study is the inclusion of Asian contact lens wearers. Ideally, we would have preferred to not include contact lens wearers because of the known association of ptosis with both hard and soft contact lens usage.^{25, 26} However, the MRD1 of the Asians was similar to the Caucasians, the PFH was comparable to other Asians in the literature, and subgroup analysis of the Asians did not show that contact lens wear affected the results.⁷ Additionally, we would have preferred to have more Asians undergo genetic analysis. However, as we were budget-limited in the number of genetics tests that could be performed, we felt it was most important to analyze all of the Latinos for this study.

Surgical Importance and Summary

For oculofacial surgery in the Latino population, identifying the location and origin of the CR and whether to address the epicanthal fold, if present, enables the surgeon to optimize outcomes. It is important to tailor the approach to the medial canthal region in order to replicate the findings of the contralateral side; this is particularly important in telecanthus repair and reconstruction after trauma or tumor excision. Moreover, having a greater appreciation for LCInc will allow both aesthetic and reconstructive surgeons to better approach this region. Creating an aesthetically pleasing LCA is an integral part of canthoplasties and may influence lower lid blepharoplasty as well as face-lifting procedures.²⁷ Understanding the normative data better prepares the surgeon to address the concerns and desired outcomes with patients preoperatively.

Our study demonstrates that many Latinos have eyelid features similar to Asians, including the presence of epicanthal folds, a more acute LCInc, and a lower CR. In our opinion, the lessons learned to optimize eyelid surgery in Asians should be applied to the subgroup of male and female Latino patients, who possess eyelid characteristics similar to Asians, such as that seen in many people originating from Mexico.

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Figure 1.

A. Periocular digital measurements: D1 (Distance 1), inner canthal distance (IC)—distance between the medial canthi (MC); D2, outer canthal distance (OC)—distance between lateral canthi (LC); D3, orbital height (OH)—distance from upper orbital rim (ORU) to lower orbital rim (ORL) denoted by a line bisecting the pupillary center; D4, palpebral fissure height (PFH)—distance from the upper lid margin (ULM) to the lower lid margin (LLM). B. A reference line is drawn from the MC horizontally toward the lateral portion of the eyelid; D5 (LCDist)—distance from the reference line to the LC; D6 horizontal fissure length (HFL)—distance from the MC to LC; D7 margin reflex distance 1 (MRD1)—distance from the pupillary center (PC) to the ULM; A1 (Angle 1)—the angle of the lateral canthal inclination relative to the MC (LCInc); A2—medial canthal angle (MCA); A3—lateral canthal angle (LCA).

Figure 2.

Graphing PC1 versus PC2 shows genetically that the three groups are clustered with the Asians on the far left, Caucasians on the far right and Latinos in the middle.

Figure 3.

A. The boxplot of IC shows the IC of the Latinos spans the range of that seen in Asians and Caucasians; B. the boxplot of the LCInc shows that Latinos span the range between Asians and Caucasians, with the latter two groups having very different degrees of obliquity of the angle; and C. the boxplot of the CR height shows that the Latinos have an eyelid crease between that of Asians and Caucasians.

Figure 4.

Four eyes showing the spectrum of the Latino lid. A. Patient with eyelid crease parallel with margin and no epicanthal fold; B. Patient with increased lateral canthal angle of inclination and minimal epicanthal fold; C. Patient with moderate epicanthal fold; and D. Patient with prominent epicanthal fold.

Table

Comparison of digital eyelid measurements between Latinos, Asians, and Caucasians

Measurement (mm or degrees)	Eye	Ethnicity	Mean	SD	Difference	Statistical Significance ^a
Margin Reflex Distance-I (MRD1)	Right	Asian	2.86	0.74	Caucasian-Asian	none
		Caucasian	3.14	0.50	Latino-Asian	none
		Latino	2.55	0.76	Latino-Caucasian	0.01+
	Left	Asian	2.91	0.65	Caucasian-Asian	none
		Caucasian	2.99	0.59	Latino-Asian	none
		Latino	2.52	0.78	Latino-Caucasian	0.05**
Palpebral Fissure Height (PFH)	Right	Asian	8.24	0.88	Caucasian-Asian	none
		Caucasian	8.58	0.89	Latino-Asian	none
		Latino	8.36	1.19	Latino-Caucasian	none
	Left	Asian	8.29	0.81	Caucasian-Asian	none
		Caucasian	8.52	0.92	Latino-Asian	none
		Latino	8.33	1.23	Latino-Caucasian	none
Lid Crease (CR)	Right	Asian	5.42	1.59	Caucasian-Asian	0.01+
		Caucasian	7.74	1.93	Latino-Asian	0.01+
		Latino	6.80	1.16	Latino-Caucasian	none
	Left	Asian	5.80	1.96	Caucasian-Asian	0.01+
		Caucasian	7.77	2.14	Latino-Asian	none
		Latino	6.80	1.27	Latino-Caucasian	none
Inner Canthus (IC)	Caucasian	Asian	33.02	2.13	Caucasian-Asian	0.01+
		Latino	28.87	2.00	Latino-Asian	0.01+
		Latino	30.89	2.67	Latino-Caucasian	0.01+
Outer Canthus (OC)	Caucasian	Asian	85.78	5.03	Caucasian-Asian	none
		Latino	84.62	4.16	Latino-Asian	none
		Latino	86.96	3.70	Latino-Caucasian	none

Measurement (mm or degrees)	Eye	Ethnicity	Mean	SD	Difference	Statistical Significance [^]
Horizontal Fissure Length (HFL)	Right	Asian	26.10	1.60	Caucasian-Asian	0.01+
		Caucasian	27.73	1.46	Latino-Asian	0.01+
		Latino	27.36	1.24	Latino-Caucasian	none
	Left	Asian	26.19	1.55	Caucasian-Asian	0.01+
		Caucasian	27.60	1.38	Latino-Asian	0.05*
		Latino	27.29	1.34	Latino-Caucasian	none
Orbital Height (OH)	Right	Asian	26.33	2.03	Caucasian-Asian	0.01+
		Caucasian	23.78	2.81	Latino-Asian	0.01+
		Latino	23.59	2.35	Latino-Caucasian	none
	Left	Asian	26.27	2.05	Caucasian-Asian	0.01+
		Caucasian	23.70	2.74	Latino-Asian	0.01+
		Latino	23.41	2.32	Latino-Caucasian	none
Medial Canthal Angle (MCA)	Right	Asian	41.34	4.59	Caucasian-Asian	0.05*
		Caucasian	35.76	5.94	Latino-Asian	0.05*
		Latino	36.52	6.33	Latino-Caucasian	none
	Left	Asian	41.22	4.89	Caucasian-Asian	0.05*
		Caucasian	35.87	5.60	Latino-Asian	0.05*
		Latino	36.38	6.63	Latino-Caucasian	none
Lateral Canthal Angle (LCA)	Right	Asian	52.79	6.03	Caucasian-Asian	none
		Caucasian	53.32	7.86	Latino-Asian	none
		Latino	53.77	8.40	Latino-Caucasian	none
	Left	Asian	53.72	6.14	Caucasian-Asian	none
		Caucasian	52.97	7.57	Latino-Asian	none
		Latino	53.01	8.52	Latino-Caucasian	none
Lateral Canthal Angle of Inclination (LCInc)	Right	Asian	8.22	1.87	Caucasian-Asian	0.01+
		Caucasian	2.34	3.40	Latino-Asian	0.01+

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Measurement (mm or degrees)	Eye	Ethnicity	Mean	SD	Difference	Statistical Significance [^]
	Left	Latino	5.96	2.19	Latino-Caucasian	0.01+
		Asian	7.79	2.94	Caucasian-Asian	0.01+
		Caucasian	2.69	2.40	Latino-Asian	none
		Latino	6.16	2.43	Latino-Caucasian	0.01+
Lateral Canthus to Reference Line (LCDist)	Right	Asian	3.74	0.92	Caucasian-Asian	0.01+
		Caucasian	1.17	1.59	Latino-Asian	0.05*
		Latino	2.80	1.01	Latino-Caucasian	0.01+
		Asian	3.54	1.36	Caucasian-Asian	0.01+
	Left	Caucasian	1.29	1.14	Latino-Asian	none
		Latino	2.90	1.14	Latino-Caucasian	0.01+

[^] = Gender adjusted ANOVA;

0.01+ = P value of less than or equal to 0.01;

0.05* = P value less than or equal to 0.05.