J Forensic Sci, May 2008, Vol. 53, No. 3
doi: 10.1111/j.1556-4029.2008.00718.x
Available online at: www.blackwell-synergy.com

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The Placement of the Human Eyeball and Canthi in Craniofacial Identification

ABSTRACT: An accurate understanding of the spatial relationships between the deep and superficial structures of the head is essential for anthropological methods concerned with the comparison of faces to skulls (superimposition) or the prediction of faces from them (facial approximation). However, differences of opinion exist concerning: (i) the position of the eyeball in planes other than the anteroposterior plane and (ii) the canthi positions relative to the bony orbital margins. This study attempts to clarify the above relationships by dissection of a small sample of adult human cadavers ($N = 4$, mean age = 83 years, $s = 12$ years). The most notable finding was that the eyeballs were not centrally positioned within the orbits as the more recent craniofacial identification literature expounds. Rather, the eyeballs were consistently positioned closer to the orbital roof and lateral orbital wall (by 1–2 mm on average); a finding consistent with the earlier anatomical literature. While these estimation errors are small ipsilaterally, several factors make them meaningful: (i) the orbital region is heavily used for facial recognition; (ii) the width error is doubled because the eyes are bilateral structures; (iii) the eyes are sometimes used to predict/assess other soft tissue facial structures; and (iv) the net error in facial approximation rapidly accumulates with the subsequent prediction of each independent facial feature. While the small sample size of this study limits conclusive generalizations, the new data presented here nonetheless have immediate application to craniofacial identification practice because the results are evidence based. In contrast, metric data have never been published to support the use of the central positioning guideline. Clearly, this study warrants further quantification of the eyeball position in larger samples and preferably of younger individuals.

KEYWORDS: forensic science, facial reconstruction, facial reproduction, orbit, globe, eye slit, palpebral fissure, projection

Methods of craniofacial identification enable a face to be predicted from a skull (facial approximation) or the degree of a match between a skull and an antemortem facial photograph to be gauged (superimposition). As faces are biological structures, an understanding of their anatomy is crucial to the success of these anthropological methods. Precision and correctness in the orbital region is especially important, particularly for facial approximation as the constructed faces are advertised to elicit facial recognitions, an event widely known to heavily depend on the morphology of the eye (1–4).

Until recently, projection of the eyeball along the anteroposterior plane had been established as first described by Wilder (5), so that the apex of the cornea touched the tangent from the anterior-most borders of the superior and inferior orbital rims (6–16). This guideline was originally formulated with respect to living people as the eye projected, when covered by closed lids, to the same level as the soft tissue borders covering the orbital margins (5). However, this guideline was extrapolated to the hard tissue using the (flawed) assumption that the soft tissue thickness over the globe and the orbital margins was identical (5). In 2002, Stephan (17) published empirical evidence that demonstrated Wilder's extrapolation to be inaccurate (globe projection was found to be underestimated by *c.* 4 mm with respect to mean exophthalmometry values from the lateral orbital margin) and the reliability of this finding was later demonstrated by other investigators using different methods (18). The eyeball position along the inferosuperior and mediolateral axes has received less scientific attention, and awaits empirical quantification. Similarly, little evidence exists to support the varied (and often contradictory) rules for positioning the canthi.

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Received 21 May 2007; and in revised form 15 Sept. 2007; accepted 13 Oct. 2007.

Within the coronal plane, placement of the eyeball is most often achieved by central positioning within the orbit (7–9,11,12; see Fig. 1). Krogman (6, p. 266), Krogman and İşcan (12, pp. 428–429), and Gatliff and Snow (10, p. 29) also report that "the apex of the cornea is at the juncture of two lines, one drawn from the medial edge of the orbit (maxillofrontale) to the lateral margin of the orbit (ectoconchion), and the other line bisecting the orbit between the superior and inferior margins" (Fig. 1). The latter guideline has no empirical support, while the former has some weak support in the form of a small sampled study ($n = 9$) conducted by Eisenfeld et al. (19) who found interpupillary measurements to be correlated with the centers of squares placed over the orbital margins ($r = 0.93$)—note here that all measurements were normalized relative to face height (19).

Whitnall (15,16), Wolff (14), and Bron et al. (20) disagree with the above authors who claim that the globe is centrally positioned. In contrast, they state that the globe falls closer to the lateral and superior orbital margins. Whitnall (15,16) specifies the distances as follows: 4 mm from the superior margin, 6.8 mm from the inferior margin; 4.5 mm from the lateral margin, 6.5 mm from the medial margin; however, he also cites Goldnamer's (21) data, which positions the globe: 4.5 mm from the roof, 6.2 mm from the floor; 4.5 mm from the lateral orbital wall, 6.5 mm from the medial orbital wall. So far, only one facial approximation practitioner has acknowledged the relationships described by Whitnall and has incorporated them into facial approximation procedures (13). Conversely, most practitioners use the (so far) empirically unjustified central positioning guideline (7–9,11,12).

As previously mentioned, many different directions have also been reported for canthi placement (Table 1). Of particular note are the disparate guidelines for horizontal positioning of the medial and lateral canthi. For example, Krogman and İşcan (12) place the canthi 3–5 mm *outside* the orbital margins, whereas other authors place the canthi *within* the orbital walls (Anastoassov and Van

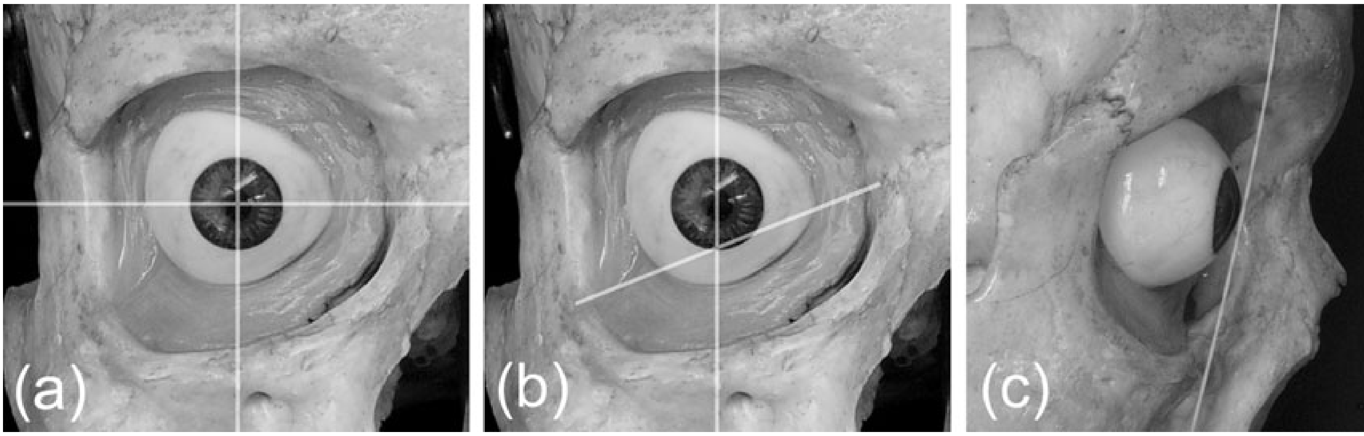

FIG. 1—*Common placement of the eyeball in facial approximation. (a) Central positioning within the orbit, relative to the coronal plane. (b) Image (a) with crosshairs positioned using the maxillofrontale (the union of the anterior lacrimal crest with the fronto-maxillary suture (34)) and ectoconchion (a moveable landmark that is the furthest lateral distance from dacryon (34)). (c) Anteroposterior positioning of the globe using the superior and inferior orbital rims following the directions of Wilder (5). Note that the tangent has been established using string placed directly over the skull before photography.*

Damme (22) place the lateral canthi as far as 13.3 mm medial to the orbit wall, while Angel places the medial canthus (MC) 2 mm lateral to the medial orbital wall). Stephan and Henneberg (23) originally attributed Krogman and İşcan's statement to a misprint; however, the original intention of these authors is clearly illustrated in diagrams (12, p. 445).

While the vertical positioning of the canthi is less controversial, prediction guidelines have little grounding in published experimental tests. The height of the lateral canthus (LC) is thought to correspond to the height of the malar tubercle (24–26) and the medial canthal ligament is said to fall at the level of the lacrimal crests (Angel (24) states that it falls 4–5 mm below the dacryon, while Stewart (27) reports a distance of 10 mm). While the attachment of the lateral canthal tendon has been consistently found to be at the malar tubercle or *c.* 10 mm below the frontozygomatic suture (16,22,26–31), whether or not it runs directly horizontal to the canthus (which is consequently at the same height) is an observation yet to be confirmed. Stewart (27) notes that the bony attachments of the medial and lateral canthal tendons are almost horizontally aligned and parallel to the canthal axis, but he did not directly compare their positions to determine whether these two planes superimpose.

Given the variety of observations and directions that exist, it would be useful to have some further empirical data concerning the matter. This study, therefore, aims to clarify these relationships.

Materials and Methods

Four cadavers were dissected, including two males and two females with a mean age of 83 years (s = 12 years). These cadavers were embalmed by the administration of *c.* 18–20 L of preservation fluid (for an average sized body) via the femoral artery. The embalming fluid comprised a 20:1 mix of Dodge® Anatomical Arterial Mixture® and Dodge® Plasdopake Tissue Texturizer® (Cambridge, MA). At the time of dissection, cadavers had been embalmed on average for 280 days (counting from the day of fluid administration; s = 55 days). During this time, all four cadavers were strictly stored in the supine position. The eyeballs in each cadaver were visually inspected prior to the cadaver's inclusion in this study to double check that the eye had not been compromised during the postmortem interval. As direct measurements could not be taken prior to dissection, empirical verifications were not possible. Therefore, the authors visually inspected the specimens for gross alterations. (For empirical evidence suggestive that minimal alteration had taken place also see the Discussion section where the similarity between the mean cadaver measures of eyeball protrusion and those of living people are presented.)

As dissection progressed from superficial to deep, measurements of the globes and canthi were taken at various times throughout the dissection process. As the medial orbital margin is not continuous, Flower's point (where the posterior lacrimal crest meets the frontal bone (16)) was used to mark the medial orbital margin (Fig. 2). The superior orbital margin was marked by its superior-most aspect; the lateral orbital margin by its lateral-most point; and the inferior orbital margin by its inferior-most point (orbitale; see Figs. 2 and 3). All measurements, except the anteroposterior distances, were taken while the skull was positioned in the Frankfurt horizontal using a craniophore (GPM®, Zurich, Switzerland). Any measurements that were not parallel to the Frankfurt horizontal were taken perpendicular to it. Sliding calipers (GPM®) were used for all measurements—except for globe projection, which was measured using a Hertel-type Western Ophthalmics® exophthalmometer (Lynnwood, WA). Each measurement was repeated three times on the same subject before averaging to achieve a final value.

Coefficients of variation of the error (CVE) were calculated for the globe measurements by examining the first value of the triplicate measures and a repeated measure taken no <24 h afterwards. Each side was included in this assessment and, therefore, there were a total of eight repeated measurements for each variable across the four cadavers. The CVE was calculated by taking the sum of the squared differences between test and retest and dividing it by two times the number of remeasured individuals. The square root of the result was taken and divided by the mean of the test/retest result for the first individual.

For the canthal measurements, the first and third of the triplicate measurements were used to calculate the CVE so as not to slow down the dissecting process. This resulted in a short time interval (minutes) between repeated measurements. As data values in this study were calculated from mean values of three repeated measurements, it is worth noting that error in the final values is likely to be less than the reported CVE.

TABLE 1— *Previously published canthi position data.*

	Anteroposterior Axis	Mediolateral Axis			Inferosuperior Axis			
	Anterior Projection of Lateral Canthus	Medial Canthus from Medial Orbital Wall	Lateral Canthus from Lateral Orbital Wall	Intercanthal Distance	Medial Canthus Height	Lateral Canthus Height	Distance of the Malar Tubercle from the Frontozygomatic Suture	Relative Height of Canthi
Angel (24) cited in Caldwell (39)		2 mm lateral	3–4 mm medial		Midpoint of lacrimal crest; 4–5 mm below dacryon	Equal to the malar tubercle		Medial 2 mm lower
Krogman and İşcan (12)		3 mm medial	5 mm lateral					
Fedosyutkin and Nainys (26)				60–80% of orbital width	Base of lacrimal crest	Equal to the malar tubercle	8.4 mm (males) 9.5 mm (females)	
George (25)			Just medial		Midpoint of posterior bord. of lacrimal crest	Equal to the malar tubercle		Medial lower
Sills (42)			1 mm medial					
Yoshino and Seta (41)		3–5 mm lateral	On or just medial					
Whitnall (16)				30 mm			11 mm	Medial 4 mm lower
Robinson and Stranc (32)		Distance from frontal process attachment: 11.7 mm lateral						
Wolff (29)			5–7 mm medial	28 mm or 70% of orbital width			10 mm	Medial 2 mm lower
Couly et al. (40)			8–10 mm medial					
Stewart (27)					10 mm below dacryon		10.5 mm	Same
Gioia et al. (30)							9.7 mm	
Anastassov and van Damme (22)	9.6 mm from Lat. Orb. Marg.		13.3 mm medial	26–27 mm			9.6 mm	
van den Bosch et al. (35)				26 mm (24 mm in elderly)				Medial 2 mm lower
Rosenstein et al. (31)			7.5 mm medial				10.2 mm	

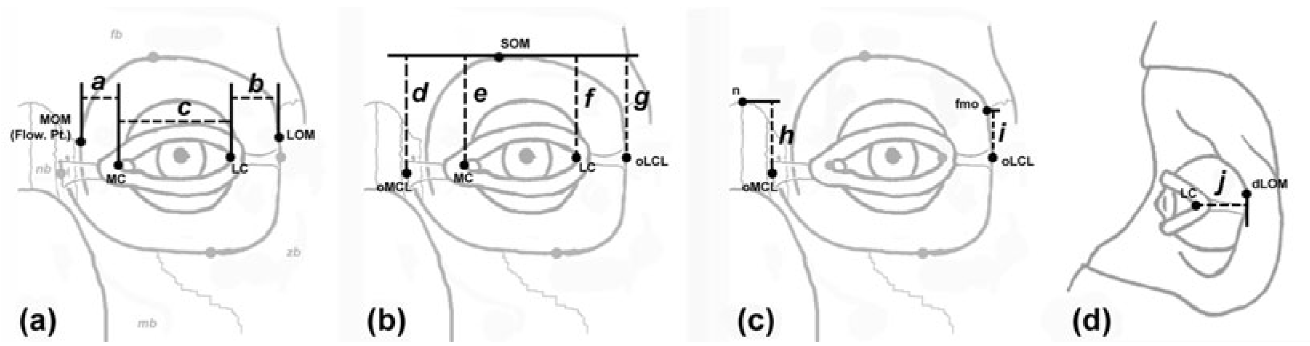

FIG. 2—*Landmarks and distances used to measure canthi position. (a) Horizontal measurements of the canthi: a = distance from the medial canthus to the medial orbital wall, b = distance from the lateral canthus to the lateral orbital wall, c = intercanthal distance. (b) Vertical measurements of the canthi: d = distance from the superior orbital wall to the origin of the medial canthal ligament, e = distance from the superior orbital wall to the medial canthus, f = distance from the superior orbital wall to the lateral canthus, g = distance from the superior orbital wall to the origin of the lateral canthal ligament. (c) Vertical measurements of the canthal ligament bony attachments: h = distance from nasion to the origin of the medial canthal ligament, i = distance from frontomalare orbitale to the origin of the lateral canthal ligament. (d) Anteroposterior measurement of lateral canthus: j = distance from the lateral canthus to the deepest recess of the lateral orbital margin. Landmarks: SOM = superior-most point on the supraorbital margin (ignoring the supraorbital notch); MOM = Flower's point (medial orbital margin); LOM = lateral-most point on the lateral orbital margin; MC = medial canthus; LC = lateral canthus; oMCL = midpoint of the medial canthal ligament's attachment to the skull; oLCL = midpoint of the lateral canthal ligament's attachment to the skull; n = nasion; fmo = frontomalare orbitale; dLOM = deepest or most posterior point on the lateral orbital margin; nb = nasal bone; mb = maxillary bone, fb = frontal bone; zb = zygomatic bone.*

Canthi Position

After removing the soft tissue from the orbital margins, but leaving the canthal ligaments and edges of the palpebral fissure intact, the horizontal distances from Flower's point to the MC and from the lateral orbital margin to the LC were measured (Fig. 2). Also measured were the intercanthal distance (Fig. 2) and the orbital height (SOM-IOM) and width (MOM-LOM; see Fig. 3).

To determine if the canthi fell at vertical levels equivalent to the canthal tendons' bony attachments, two measurements were taken and subtracted from each other for each side of the head. With regards to position of the MC, the distance between it and the supraorbital margin (SOM) was subtracted from the distance between the SOM and the midpoint of the medial canthal ligament's bony origin (oMCL; see also Fig. 2). For the LC, the distance between it and the SOM was subtracted from the distance between the SOM and the midpoint of the lateral canthal ligament's bony origin (oLCL; Fig. 2). Also the vertical levels of the medial and lateral canthi were assessed in relation to each other by measuring, from the SOM, the distance to each and subtracting the lateral measurement from the medial one (Fig. 2). So that more robust measurements were obtained, the distances to fixed points were also measured. This included the height of the center of the medial canthal ligament's origin to nasion, and the height of the center of the lateral canthal ligament's origin to frontomalare orbitale (Fig. 2). The placement of the LC along the anteroposterior axis was also determined by measuring the distance between the LC and the deepest portion of the lateral orbital margin (dLOM) using sliding calipers (Fig. 2).

Eyeball Position

After the soft tissue lying adjacent and anterior to the geometric equator of the globe had been removed, the eyeball position was

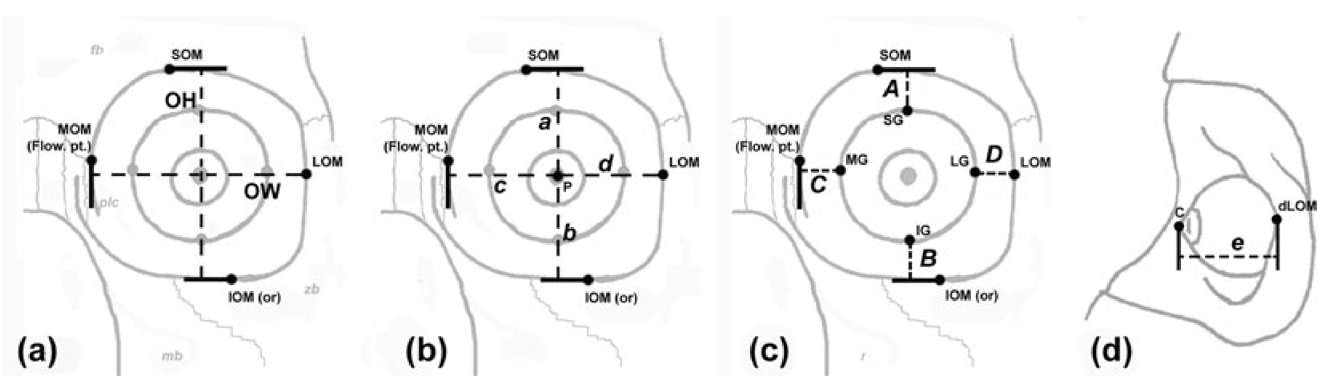

FIG. 3—*Landmarks and distances used to measure the globe position. (a) Measurements of orbital dimensions: OH = orbital height, the distance between the supra- and infraorbital margins, OW = orbital width, the distance between the medial and lateral orbital margins. (b) Measurements from the pupil in the coronal plane: a = distance from the pupil center to the supraorbital margin, b = distance from the pupil center to the infraorbital margin, c = distance from the pupil center to the medial orbital margin, d = distance from the pupil center to the lateral orbital margin. (c) Measurements from the globe equator in the coronal plane: A = distance from the superior globe edge to the supraorbital margin, B = distance from the inferior globe edge to the infraorbital margin, C = distance from the medial globe edge to the medial orbital margin, D = distance from the lateral globe edge to the lateral orbital margin. (d) Measurement from the corneal apex in the anteroposterior direction: e = distance from the corneal apex to the deepest recess of the lateral orbital margin. Landmarks: IOM = inferior-most point on the infraorbital margin (orbitale); P = pupil center, SG = superior-most point of the equator of the eyeball, IG = inferior-most point of the equator of the eyeball, MG = medial-most point of the equator of the eyeball, LG = lateral-most point of the equator of the eyeball, C = apex of the cornea. (For other landmark definitions see captions for* Fig. 2.)

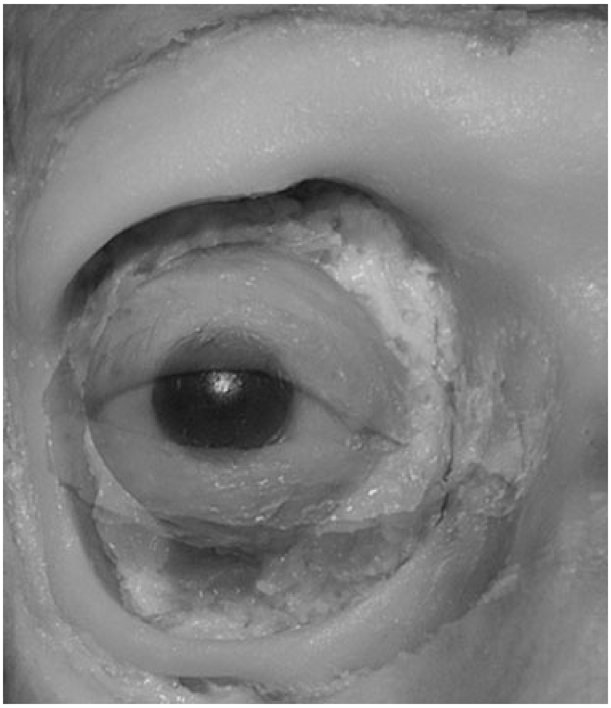

FIG. 4—*Superimposition of right orbital regions from one specimen before and after removal of the canthi and supporting soft tissue to demonstrate continued fixation of the eyeball within the orbit after soft tissue removal.*

measured in the coronal plane using two different methods. First, the distance between the center of the pupil and each orbital margin was measured (Fig. 3). Second, the distance between each of the four globe edges and their respective orbital walls was measured (Fig. 3). These two methods were used to ensure that useful results were obtained in the case that the pupils had not been facing directly ahead (this was difficult to judge until the dissection was well underway). As the globe is "suspended" in fat within the orbit, special care was taken to ensure that only the smallest necessary amount was removed, so that the remainder continued to hold the globe in its original position. To check that the globe had not moved during dissection, photographic superimpositions were made of the specimens (while mounted in the craniophore) before and after removal of the eyelids (Fig. 4).

Eyeball divergences from the center of the orbit were calculated by subtracting the lateral from medial measurements and superior from inferior measurements and dividing by two. If there was no divergence from the center, a value of zero was obtained; if there was divergence from the center, it was measured in millimeters. Anterior eyeball projection, taken as the distance from the deepest portion of the lateral orbital wall to the corneal apex (Fig. 3), was also measured using the above mentioned exophthalmometer.

Results

Coefficients of Variation of the Error

Coefficients of variation of the error for all measurements made in this study are reported in Table 2. CVEs were generally low, but higher for smaller measurements as expected. Overall, they generally fell within acceptable limits (<5–10%). Statistical significance tests were not used to compare repeated measurements as the samples sizes were small, and thus the power to detect any differences were limited.

TABLE 2—*Coefficients of variation (CVE) of the error for measurements made in this study.*

	CVE (%)	Data Used
Orbital dimensions (Fig. 3)		
Orbital height (SOM-IOM)	1.1	1st and retest
Orbital width (MOM-LOM)	1.2	1st and retest
Canthal measurements (Fig. 2)		
MOM-MC (*a*)	10.5	1st and 3rd
LOM-LC (*b*)	12.6	1st and 3rd
MC-LC (*c*)	2.3	1st and 3rd
SOM-oMCL (*d*)	3.2	1st and 3rd
SOM-MC (*e*)	1.8	1st and 3rd
SOM-LC (*f*)	3.0	1st and 3rd
SOM-oLCL (*g*)	3.1	1st and 3rd
n-oMCL (*h*)	3.5	1st and 3rd
fmo-oLCL (*i*)	7.2	1st and 3rd
dLOM-LC (*j*)	5.7	1st and 3rd
Eyeball measurements (Fig. 3)		
SOM-P (*a*)	3.0	1st and retest
IOM-P (*b*)	2.9	1st and retest
MOM-P (*c*)	4.0	1st and retest
LOM-P (*d*)	5.6	1st and retest
SOM-SEG (*A*)	10.5	1st and retest
IOM-IEG (*B*)	7.0	1st and retest
MOM-MEG (*C*)	11.3	1st and retest
LOM-LEG (*D*)	6.7	1st and retest
dLOM-C (*E*)	2.1	1st and retest

Canthi Position

The MC was, on average, 4.8 mm lateral to the medial orbital wall, but the anterior limb of its ligament was also observed to project to the frontal process of the maxilla and the nasal bones as recorded by other authors (32). In every case, the MC was found lateral to the medial orbital wall. The distance of the LC from the lateral orbital wall was found to be 4.5 mm on average, and for all subjects it was found medial to the lateral orbital wall.

The MC was at the same level as its ligament's central point of attachment to the bone (mean diff = −0.3 mm with the origin being higher than the canthus), which was 12 mm below nasion (Table 3). The LC was also found to be at the same height as its ligament's bony origin (mean diff = 0 mm), which was 8 mm below the frontomalare orbitale point (Table 3). In three of four individuals, the MC fell slightly lower than the LC with a mean difference of 1 mm. The distance between the canthi of each eye averaged 24.5 mm, which represented *c.* 74% of the total orbital width. The LC projected an average of 10-mm anterior to the deepest recess of the lateral orbital margin.

Eyeball Position

The pupil of one cadaver did not face directly forward, so this individual was excluded from the pupil center measurements. These results were, therefore, based on three cadavers, while the measurements from the globe periphery are based on four individuals. The mean distance from the pupil center to the superior orbital margin was 16.2 mm; the inferior orbital margin was 18.3 mm; the lateral orbital margin was 14.8 mm; and the medial orbital margin was 17.8 mm. The distance from the globe equator to the superior orbital margin was 5.1 mm; the inferior orbital margin was 7.8 mm; the lateral orbital margin was 4.0 mm; and the medial orbital margin was 7.0 mm.

The mean divergence of the globe from the center of the orbit horizontally, using either the pupil or the globe edges as reference points, was 1.5 mm in the lateral direction (the equivalent of 5% of the orbital width). The mean divergence of the globe from the

TABLE 3—*Summary table of data collected from dissections in this study.*

	Mean	*s*	Min.	Max.	*n*
Orbital dimensions (mm; Fig. 3)					
Orbital height (SOM-IOM)	34.9	2.5	31.5	37.0	4
Orbital width (MOM-LOM)	33.0	1.6	31.5	35.0	4
Canthal measurements (mm; Fig. 2)					
MOM-MC (*a*)	4.8	0.3	4.5	5.0	4
LOM-LC (*b*)	4.5	2.0	2.5	7.0	4
MC-LC (*c*)	24.5	2.4	21.0	26.5	4
MC-LC/orbital width (%)	74.2	6.4	65.6	81.0	4
SOM-oMCL (*d*)	19.3	1.2	18.0	20.5	4
SOM-MC (*e*)	19.5	1.9	17.0	21.5	4
SOM-oMCL minus SOM-MC ($d - e$)	-0.3	1.8	-3.0	1.0	4
SOM-LC (*f*)	18.5	2.0	16.5	20.5	4
SOM-oLCL (*g*)	18.1	1.0	17.0	19.0	4
SOM-oLCL minus SOM-LC ($g - f$)	0.0	2.0	-2.5	2.5	4
SOM-MC minus SOM-LC ($e - f$)	1.0	1.8	-0.5	3.5	4
n-oMCL (*h*)	12.1	1.1	11.0	13.5	4
fmo-oLCL (*i*)	7.9	1.4	6.5	9.5	4
dLOM-LC (*j*)	9.8	2.3	6.5	11.0	4
Eyeball measurements (mm; Fig. 3)					
SOM-P (*a*)	16.2	1.3	15.0	17.5	3
IOM-P (*b*)	18.3	1.2	17.0	19.0	3
MOM-P (*c*)	17.8	2.0	16.0	20.0	3
LOM-P (*d*)	14.8	1.5	13.5	16.5	3
SOM-SEG (*A*)	5.1	2.2	3.0	8.0	4
IOM-IEG (*B*)	7.8	1.2	6.5	9.0	4
MOM-MEG (*C*)	7.0	1.8	5.5	9.0	4
LOM-LEG (*D*)	4.0	1.5	2.0	5.5	4
dLOM-C (*E*)	15.0	4.4	11.0	19.5	4

center of the orbit vertically, was 1.1 mm superiorly for the pupil measures (or the equivalent of 3% of the orbital height), and 1.4 mm superiorly for the globe edge measurements (or the equivalent of 4% of the orbital height). This gave a mean of 1.3 mm of superior displacement across the two measurement methods. For the measurements from the globe periphery, three of four cadavers displayed more lateral and more superior positioning in comparison to the central orbital point. The mean anterior projection of the globe, measured from the corneal apex to the deepest recess of the lateral orbital margin was 15.0 mm (Table 3). Front and profile photographs of the globe position in all four cadavers are presented in Fig. 5.

Discussion

The results of this study do not support the recent and most commonly used guidelines for mediolateral and inferosuperior positioning of the globe. Rather this study supports much earlier observations of Whitnall (15,16), Wolf (14), Goldnamer (21), and Bron et al. (20) that the eyeball is located more superiorly and laterally. While the mean divergence on each side from the center was small (between 1.2 and 1.5 mm or 3–5% of the total orbital width), the error is doubled for interpupillary values as the eyes are bilateral structures. This degree of error is unacceptable with respect to approximation of the eyes because (i) the orbital region is an important area of the face for facial recognition (1–4); (ii) the eyes are sometimes used to predict/assess other soft tissue facial structures (9,12,33); and (iii) the net error in facial approximation rapidly accumulates with the subsequent prediction of each facial feature. As the guideline using the maxillofrontale and the ectoconchion is likely to place the pupil inferior to the center of the orbit (34), this guideline seems even less favorable than the central positioning guideline.

The horizontal measurements of canthi position from the orbital rims suggest that the distance from the medial orbital wall to the MC is slightly larger than the distance of the LC from the lateral

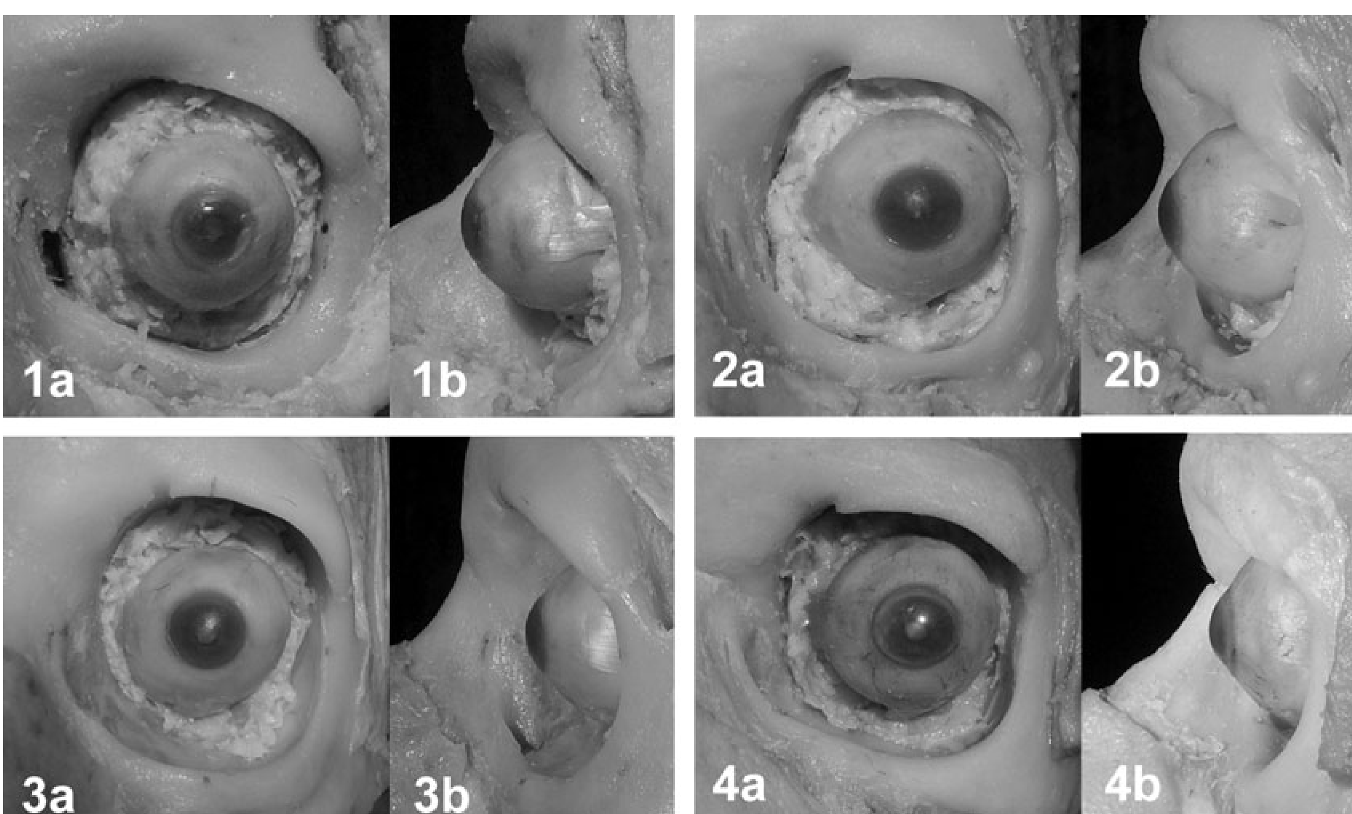

FIG. 5—*Frontal and profile views of globe position in all four dissected specimens (left side).*

orbital wall. This finding is logical in light of the result that the globe lies closer to the lateral orbital wall than the medial orbital wall. The distance that the LC was found from the lateral orbital wall was greater than values reported in some studies (Table 1); however, they were also less than others (seemingly because these latter investigations made measurements along the long axis of the canthal ligament, not in the coronal plane (30)). The intercanthal distance was comparable to those of other studies, particularly that of van den Bosch et al. (35), who also measured elderly subjects; but note here that palpebral fissure length appears to be slightly smaller in older as compared to younger individuals (35).

The distance from the lateral canthal ligament's bony attachment to the frontomalare orbitale (or anterior side of the frontozygomatic suture) was slightly smaller in this study in comparison to the distance reported between the frontozygomatic suture and the malar tubercle by other authors (Table 1). As this study did not measure the height of the medial canthal ligament to dacryon (since this landmark was obscured by soft tissue at the time of measurement and stage of the dissection), no comparisons can be made with the other studies that used it (24,27). Consistent with the findings of Stewart (27) and reports of palpebral fissure obliquity by other authors (36) we found the lateral canthi to be positioned slightly higher than the medial canthi. The observed height difference between the canthi equaled 1 mm, which is consistent with the findings of Stewart (27), similar to the findings of Farkas et al. (37), van den Bosch et al. (35), Angel (24), and Wolff (29), but considerably less than the 4 mm reported by Whitnall (16). Our findings also contradict reports by Anastassov and van Damme (22) that individuals aged more than 50 years have lower lateral than medial canthi.

This investigation also found the LC to project *c.* 5 mm less from the lateral orbital margin than the globe, and that these two values co-varied ($r = 0.86$). Studies using photographs of living individuals report that the distance between the LC and the corneal apex to be twice as large (35,38).

As the globe projection values for cadavers of this study were highly comparable to values reported for living people (Fig. 6), it seems unlikely that the use of cadavers compromised the value of this study in this respect. Also note here, that Anastassov and van Damme (22) found the pupillocanthal distances to be similar between living patients and "fresh" cadavers adding further weight to the value of cadaver based investigations for the examination of the canthal positions. However, it should be noted here that we found the lateral canthus to corneal apex distance to be halved in cadavers in contrast to other reports in living subjects, as reported above. The similarity of this study's globe projection data to much larger sampled studies also provides evidence that the mean values generated from this small sample are indicative of population means. Based on these observations, and the consistency of globe position results with other evidence based investigations (16,21), the findings of this study have immediate applicability to craniofacial identification methods. These results warrant future larger-sampled studies of the orbit in younger adults to provide additional insights into the relationship between the skull and face.

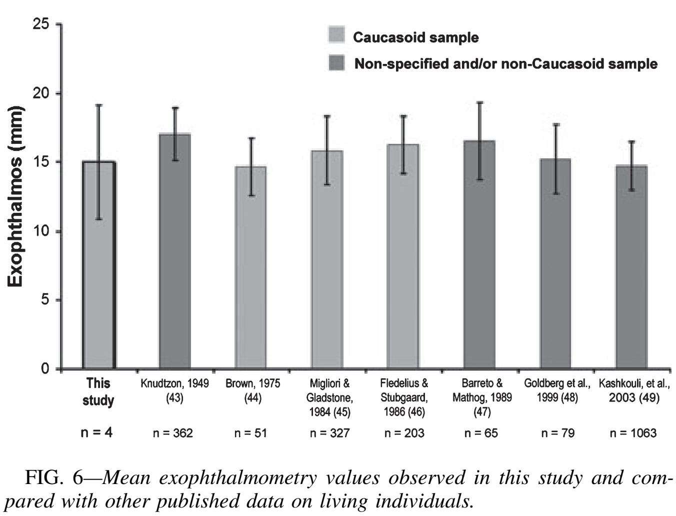

FIG. 6—*Mean exophthalmometry values observed in this study and compared with other published data on living individuals.*

Acknowledgments

Special thanks go to staff at the University of Queensland's Anatomy Laboratory for technical assistance and to two anonymous reviewers who provided helpful comments on an earlier draft.

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