Vertical Localization of the Malar Prominence

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**Background:** During reconstruction or augmentation, it is important to localize the malar complex in a symmetrical and aesthetically pleasing position. Few studies have determined the location of this feature and none related the location to gender, age, or ethnicity. Some of these have attempted to relate the position to the aesthetically pleasing Golden Ratio φ.

**Methods:** We assessed the vertical location of the malar prominence relative to other facial landmarks, determined consistency among individuals, and compared this with values used in artistry. Study population consisted of a convenience sample of 67 patients taken from an otolaryngology practice at a large urban medical center. Coordinates of the malar prominence were referenced to distinct facial landmarks from which the ratio of chin-to-malar prominence to chin-to-eye canthus was determined.

**Results:** Average chin-to-malar prominence distance was 0.793 ± 0.023 (SD) of the chin-to-eye canthus distance. Variability due to the specific image chosen [coefficient of variation (CV) = 1.19%] and combined inter/intra-reader variability (CV = 1.71%) validate the methodology. Variability among individuals (CV = 2.84%) indicates population consistency. No difference was found between gender and age groups or between whites and Hispanics. Individuals of other/unknown ethnicities were within the range common to whites and Hispanics. Our population’s value is not different from the value of 0.809 used in artistry, which is based on the Golden Ratio φ.

**Conclusions:** The vertical position of the malar prominence is consistent among individuals, is clinically well-approximated by the value based on the Golden Ratio, and may be useful as a reference for surgical reconstruction or augmentation. (Plast Reconstr Surg Glob Open 2015;3:e411; doi: 10.1097/GOX.0000000000000383; Published online 3 June 2015.)

Beauty is a complex phenomenon intrinsic to interactions between individuals. It is generally agreed that facial beauty is related to vertical and horizontal proportions of various facial features. Universal beauty, however, is almost impossible to define because of differences in time, culture, ethnicity, and age. The surgeon, however, relies on certain facial proportions and relationships to provide a basis for diagnosis and planning in facial plastic surgery.

Previous studies have addressed ideal vertical and horizontal proportions of facial features. Few of these have addressed the location of the malar or zygomatic prominence, as it is a less distinct landmark than other facial features and its position is difficult to define. The cheekbone, however, “is the second most frequently fractured bone on the craniofacial skeleton” (Donald PJ, quoted in Czerwinski et al1), and accurate localization is important for surgical reconstruction. Although vertical positioning of the malar prominence is in common usage during facial

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Various previous studies have related ideal vertical and horizontal facial proportions to the Golden Ratio, or “phi,” \( \varphi \). The Golden Ratio, also known as the Divine Proportion, is that which is obtained when one divides any length into two parts in which the ratio of the larger part to the smaller is the same as that of the whole to the larger part. This ratio, \( \varphi \), is an irrational number whose value is \( \frac{\sqrt{5} + 1}{2} \approx 1.618 \).

Prendergast \(^8\) also describes division of the face into thirds. In these, the face is divided roughly into thirds—upper third from hairline to glabella, middle third from glabella to subnasal, and lower third from subnasal to menton. The lower two thirds can each be further divided into 3 parts—in essence dividing the face roughly into ninths. In both of these, the malar prominence appears within the middle third, at about four ninths from the chin, and the eye canthus appears at about five ninths from the chin. The malar prominence is thus found at approximately four fifths of the distance from chin to eye canthus. This value, 0.8, is almost identical to the value of 0.809, which is based on the Golden Ratio.

Prendergast and Schoenrock \(^10\) measured the location of several facial landmarks, including the horizontal and vertical position of the malar eminence in a small group of subjects. Twenty models were used, all of whom were white women except 1 black and 1 Asian model who were “judged to have white faces.” The location of the malar eminence was found to be similar to the values obtained using either the Golden Ratio or the trisection of the face.

Our purpose was to evaluate the vertical location of the malar prominence with respect to facial landmarks (chin and eye) in a large group of subjects and to determine whether the location of this feature was consistent among individuals. We also assessed whether any measured differences were associated with gender, age, or ethnicity. The value we obtained for the vertical position—that is, ratio of cheek height to eye height—was then compared with the values based on the Golden Ratio or used in artistry as a proxy for attractiveness. Our study comprises a larger cohort than any of the previous articles. Moreover, we have a mixed population with respect to age, gender, and ethnicity, and subjects were not selected based on attractiveness. No previous studies have examined the location of the malar prominence with respect to gender, age, or ethnicity in a population that was not selected for attractiveness. These results may be more applicable to the population in general.
METHODS/DESIGN

Our population consisted of 67 patients being evaluated for rhinoplasty at the otolaryngology practice of a large urban medical center. There were 35 males and 32 females. Ages were available for 57 subjects ranging from 16 to 69 years. There were 29 whites, 9 Hispanics, 2 Pacific Islanders, 1 Asian, 1 black, 4 “others,” and 21 unspecified. Complete demographic data were not available for some patients as they were no longer under clinical care or providing these data had been declined. This study group was a sample of convenience; however, it does represent the patient population of this particular clinical setting. Written consent had been obtained from each patient for the use of photographs for research purposes. This study was Institutional Review Board-approved.

Data Collection

The first acceptable photograph from each patient’s set was selected based on the following criteria: heads were turned obliquely (slight turn so that the far ear is no longer visible while maintaining a clear view of the far cheek outline), facing directly forward, eyes open, and neutral facial expression. Images that distorted or obscured landmarks of interest, including images with closed eyes, large beards, open mouths, smiling expressions, and other facial distortions, were excluded. Oblique views of patients’ faces were chosen so that the cheek farthest from the viewer could be seen in profile and the malar prominence could be readily located. The malar prominence was defined as the most prominent part of the cheek when using oblique views. As such, it represents a combined soft tissue/hard tissue landmark. Care was taken to distinguish the cheekbone from fatty submalar areas in heavier or older patients who empirically locate the cheek.

Digital photographs were cropped to include the head and neck and resized to 6” wide, without changing vertical-to-horizontal aspect. Photographs were pasted onto an 8.5" × 11" graph in SigmaPlot, version 10 (Systat Software, Point Richmond, Calif.). This program was chosen because it allows one to read the coordinates of any point simply by placing the cursor at that location, regardless of the zoom or the portion of the image displayed.

Coordinates of pupil centers, lateral canthi, commissures of the mouth, the menton (base of the chin), and the malar prominence were recorded (Fig. 2). Three independent readers determined the (x,y) coordinates of the most prominent part of the cheek on the far side of the face (Fig. 2).

The relative vertical position of the malar prominence was calculated as follows (Fig. 2): Straight...
lines projecting through the lateral canthi of the eyes and through the lateral commissures of the mouth were calculated. In an oblique view, these lines meet at the vanishing point (outside the figure boundaries). Lines were then calculated from the vanishing point to the tip of the chin and from the vanishing point through the estimated location of the malar prominence. At the \((x,y)\) coordinates of the malar prominence, a vertical line was calculated from the canthus line down to the chin line. We then calculated the distance from chin to malar prominence relative to chin to canthus, using vertical distances at this \(x\) coordinate. That is, we calculated the ratio of line \(a\) to line \(b\) as seen in Figure 2. The values \(a/b\) for each reading for each patient—that is, the ratios of malar prominence height to canthus height, relative to the base of the chin—were then used for further analyses. (In addition to using the location of eye canthus, the center of the pupil was also used to determine malar prominence height to pupil height.)

Student’s \(t\) tests were used to compare subgroups of patients and to compare our population’s average ratio to the predicted values of either 0.809 or 0.8. Chi-square test was used to determine whether the number of individuals with cheek height ratio greater than the predefined values of either 0.809 or 0.8 was the same as the number of individuals with cheek height ratio less than these values.

**RESULTS**

**Variability due to Image Selection**

To determine the validity of our method, one reader recorded coordinates for the malar prominence location on 6 different oblique-view images available for one subject. This was done to determine how much variation in cheek height determination was dependent on the selection of photograph used. The malar prominence position was determined by a single reader to minimize reader variability. The average cheek height ratio for this subject was found to be 0.817 ± 0.010 (SD) \([\text{coefficient of variation} (CV) = 1.19\%]\) (Table 1). Variability due to the specific image chosen was found to be less than that associated with other factors (see below).

**Variability due to Analyst Interpretation**

Differences for the cheek height ratio due to readers’ interpretation of the images were examined next. The coordinates of the malar prominence for 5 subjects were determined 5 times each by 3 different readers to establish inter- and intrareader variability. Within-reader, between-reader, and total combined SD\(^{11}\) were determined (Table 2). The average total SD for the \(x\) coordinate readings (the edge of the face at the level of the malar prominence) was 0.0080\(^\circ\) and for the \(y\) coordinate (the vertical position of the malar prominence on the facial image) was 0.0582\(^\circ\). Reading of the lateral position of the face at the height of the cheek (\(x\) coordinate) is more precise than estimation of the vertical position of the cheek (\(y\) coordinate) due to the edge of the face being easier to define than the vertical position of the cheek.

Variability due to reading the position of the malar prominence translates into a variability in the determination of the chin-to-cheek:chin-to-canthus ratio of \(±0.014.\)\(^{12}\) Thus, average cheek height ratio for these 5 subjects was 0.798 ± 0.014 (SD). CV due to combined within-reader and between-reader variation is thus 1.71%.

**Variability among Patients**

Each reader made one determination of the coordinates for the remaining patients. Chin-to-cheek height as a proportion of chin-to-lateral canthus and also chin-to-pupil height was determined for the 67 subjects.

The average ratio of cheek height to canthus height was found to be 0.793 ± 0.023 (SD) \((CV = 2.84\%)\), with values ranging from 0.710 to 0.829. Of the 67 patients, 53 had ratios less than 0.809 and 14 greater than 0.809 \((P = 0.000002)\). Similarly, 40 had ratios less than 0.8 and 27 greater than 0.8 \((P = 0.11)\).

The average ratio of cheek height to pupil height was found to be 0.777 ± 0.023 (SD) \((CV = 2.90\%)\) Values ranged from 0.706 to 0.820. For the 67 patients, 64 had ratios less than 0.809 and 3 greater than 0.809 \((P < 0.000001)\). Similarly, 58 had ratios less than 0.8 and 9 greater than 0.8 \((P < 0.000001)\).

**Table 1. Variability due to Different Images**

| Patient Image* | Vertical Malar Prominence Location
|----------------|---------------------------------|
|                | Chin to Malar Prominence:Chin to Canthus Ratio |
| 1—right side, 2/3 to 3/4 rotation | 0.823 |
| 2—left side, 2/3 rotation | 0.818 |
| 3—right side, 2/3 rotation | 0.825 |
| 4—left side, 3/4 rotation | 0.799 |
| 5—right side, 3/4 rotation | 0.815 |
| 6—left side, 2/3 to 3/4 rotation | 0.822 |
| Average | 0.817 |
| SD | 0.010 |
| SEM | 0.001 |

*Rotation is defined as the following: 2/3 view—slight turn so that far ear cannot be seen; 2/3 view—slightly more than 3/4, so that the line of the nose is almost touching the outline of the cheek on the far side, but not breaking the outline of the cheek.
Demographic Differences

The difference between the cheek height ratios of males (N = 35) versus females (N = 32) was examined (Fig. 3). For males, cheek height ratio based on canthus was found to be 0.794 ± 0.023 (SD). For females, this was 0.793 ± 0.023 (SD). These are not different (P = 0.86).

For those subjects for whom age data were available, we examined whether there was a difference between the lower and upper half of the population or between the lower and upper third (Fig. 3). For the lower half, 30 years and below (N = 27), the cheek height ratio based on the canthus was 0.791 ± 0.020 (SD). For the upper half, 31 years and above (N = 30), the ratio was 0.795 ± 0.027 (SD) (P = 0.53). For the lower third, 16–25 years (N = 19), the ratio was 0.789 ± 0.020 (SD). For the upper third, 37–69 years (N = 20), the ratio was 0.795 ± 0.028 (SD) (P = 0.45). We also grouped the subjects by decades of age (Table 3). Malar prominence height ranged from 0.782 ± 0.036 (SD) for age group 40–49 to 0.802 ± 0.012 (SD) for age group 50–59. There was no difference among the age groups, and we noted that there was no trend with increasing age despite this being a combined soft tissue/hard tissue landmark.

To determine whether cheek height varied by ethnicity, the 2 largest ethnic groups, whites and Hispanics, were compared (Fig. 3). The cheek height ratio based on the canthus was 0.788 ± 0.021 (SD) for whites (N = 29) and was 0.802 ± 0.023 (SD) for Hispanics (N = 9) (P = 0.13). Of the 29 individuals who were of different or unknown ethnicity, all but one had malar prominence height within the range common to the 95% confidence interval of both whites and Hispanics (0.750–0.831). This one subject had a malar prominence height of 0.710.

Table 3. Malar Prominence Height Ratio in Various Age Groups

| Age Groupings | 10–19 Years | 20–29 Years | 30–39 Years | 40–49 Years | 50–59 Years | 60–69 Years |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Number        | 6           | 18          | 18          | 7           | 4           | 4           |
| Mean          | 0.792       | 0.792       | 0.797       | 0.782       | 0.802       | 0.792       |
| SD            | 0.016       | 0.022       | 0.023       | 0.036       | 0.012       | 0.027       |
| SEM           | 0.007       | 0.005       | 0.006       | 0.014       | 0.006       | 0.013       |

For this subject, the measured distance from chin to canthus is 10.8 cm, and the difference between our population’s average malar prominence height and the Golden Ratio height is 1.73 mm.
DISCUSSION

Small CVs Imply Appropriate Methodology

There are 3 sources of variability when calculating cheek height ratios of patients: (1) different images of the same individual (CV = 1.19%); (2) reader measurement differences (CV = 1.71%); and (3) patient differences (CV = 2.84%). Different images of the same individual showing different sides of the face and with different degrees of rotation all yielded essentially the same result. This validated the methodology used. The low values for the first two reflect high precision in the reading of facial coordinates and the last reflects consistency among individuals.

This indicates that our methodology is appropriate to measure the vertical position of the malar prominence relative to facial features. In turn, this allows us to investigate demographic differences and to test the applicability of values used in artistry.

Demographic Differences

No differences were found in the cheek height ratios between males and females or between adults of different ages. Our findings for age are consistent with Richardson’s reproduction of Schadow’s work, in which age does not seem to affect the vertical position of the malar prominence as it is shown at the same relative position in all individuals from infants to old age. There was no difference between our 2 most predominant ethnic groups (whites or Hispanics), and individuals who were not classified into these 2 groups had similar values. Even if a statistically significant difference could be shown, it would unlikely be a clinically relevant difference.

Comparison with Previous Literature

Prendergast and Schoenrock10 provide data for facial landmarks viewing the face both from the front and the side. For frontal views, the vertical height from menton to nasion was set at 1.0. The average medial canthus height was 0.97±0.02, the pupil height 1.01±0.03, and the height of the malar eminence 0.82±0.06. The lateral canthus height was not measured in the frontal view.

Using the medial canthus as the reference, the malar eminence was found by Prendergast and Schoenrock10 to be 0.845 of the chin to medial canthus distance (calculated SD = 0.064; calculated CV = 7.6%)12 compared with our value, also referenced to pupil position, of 0.777±0.023(SD) (CV = 2.90%). The lower value for the malar prominence ratio when using the pupil as a reference point rather than the canthus reflects the fact that the pupil is located farther from the chin than either canthus when the subject is looking directly forward (Fig. 1). Although the relative height reported by Prendergast and Schoenrock10 is similar to the value we obtained, the difference is significant (P = 0.0003), perhaps reflecting slight differences in where the subject’s gaze is directed, differences in methodology for measuring these features, differences in defining the position of the malar prominence in frontal, lateral, or oblique view, or different populations being studied.

When considering the lateral view of a face, the lateral canthus height was found by Prendergast and Schoenrock10 to be 0.96±0.05 and the height of the malar eminence 0.77±0.04. The relative height of the malar eminence referenced to the lateral canthus was 0.802 (calculated SD = 0.059; calculated CV = 7.35%)12—which is not different from our value of 0.793±0.023(SD) (CV = 2.84%) (P = 0.31).

Comparison with Values Used in Artistry

Our population’s average cheek height was compared with the value of 0.809, which is based on the Golden Ratio, φ (Fig. 1). The population’s ratio of cheek height to canthus height is 0.793±0.003 (SEM). The ratio of cheek height to pupil height is 0.777±0.003 (SEM). These represent 98% and 96%, respectively, of the value predicted using the Golden Ratio, in agreement with the findings of Ricketts. However, average cheek height for our population is statistically different from the height based on the Golden Ratio (P<0.000001 for both), although individual patients may be either above or below this value. Marquardt13 constructed a “Phi Mask” in which various facial features are positioned based on the Golden Decagon, which itself is based on the Golden Ratio, φ. Prendergast6 comments that this “Phi Mask” yields a face with high cheekbones, an observation that would be consistent with our finding that the cheekbones are slightly lower than the value of 0.809, which is based on φ.

When compared with the value of 0.8, based on the trisection of the face, our population’s value of cheek height to pupil height of 0.777±0.003 (SEM) is significantly different (P < 0.000001). The value of cheek height to canthus height of 0.793±0.003 (SEM) is also different from the value of 0.8 (P = 0.021).
Our population’s cheek height, on average, is not clinically different from either the value of 80.9% or 80% of canthus height. For the individual shown in Figure 3, the height from chin to canthus is 10.8 cm and the malar prominence, as determined from Figure 2, is found to be at 8.72 cm. Using the Golden Ratio parameters, the malar prominence would be predicted to be at a height of 8.74 cm; using the value of 80%, the height would be predicted to be at 8.64 cm; and using the average for our population, the height would be predicted to be at 8.56 cm. The difference between these is, at most, only 1.73 mm. It has been suggested that “surface facial asymmetry of 2 mm was … discernible to a trained physician 50 percent of the time.” Similarly, Chu et al have shown that asymmetry of 3 mm is visually discernible. Any deviation from the 0.809 ratio that is less than 2–3 mm may not be visibly discernible, especially for a landmark that is quite indistinct. Cheek height proportions of our population therefore clinically align with that expected based on both the Golden Ratio and using trisection of the face.

Our study population was unselected with respect to “attractiveness.” Regardless, the cheek height in our population is very consistent. The malar prominence height we have determined therefore does not indicate a value representing “attractiveness” but is representative of “average-ness” in our clinical practice. However, it agrees to within 2 mm, with the height determined using Golden Ratio proportions. The value we obtain for the height of the malar prominence for subjects in our clinical practice (79.2% of the chin to eye canthus distance) agrees with the value claimed to define attractiveness (80.9%) and with a value used to define cheek height in artistry (80%). Thus, this lends credence to the suggestion that this value can be used in a clinical setting to approximate cheek height for average-looking patients in need of reconstructive or cosmetic surgery.

Significance

This study is significant for several reasons: It constitutes a much larger and more diverse population than previous studies. Furthermore, patient images are not required to be direct frontal views: anything from a frontal to an almost profile view can be used, provided the landmarks can be located and the location of the malar prominence can be determined. Our method analyzes photographs rather than requiring patient presence and is simple and convenient. Although reconstructive surgery of the malar prominence is common, and has not necessarily used a definitive value for the vertical localization, this study may validate values that are in current use-

CONCLUSIONS

This study has determined the vertical position of the malar prominence relative to facial landmarks using a larger and more diverse patient population than previous studies. Average chin-to-malar prominence distance was $0.793 \pm 0.023$ (SD) of the chin-to-eye canthus distance. No previous studies have examined this with respect to gender, age, or ethnicity while excluding the factor of “attractiveness.” The high precision of the measurements and the small variability among subjects indicate that the relative location of the malar prominence is consistent among individuals. Eighty-six percent of our population had the malar prominence located within 3 mm of the average (calculated assuming chin-to-lateral canthus height is 10.8 cm, as for the individual in Fig. 3). We found no significant differences in a population unselected for attractiveness between the two genders, among different age categories, or between whites and Hispanics, with individuals of other/unknown ethnicities having values consistent with those found for whites and Hispanics.

The secondary purpose was to compare the observed height of the malar prominence with an aesthetic value derived from the Golden Ratio (0.809 of the chin to eye canthus distance). We found that the observed height was slightly below the derived value but did not differ from it clinically.

The results of our study may be of use in the clinical setting. The value for the malar prominence being 80% of the distance from chin to eye canthus can be used as a basis for reconstructive or augmentative...
surgery, when procedures involve more than simply matching an artificially constructed malar prominence to that of the contralateral side, although it should not be the sole determining factor. This value is consistent with aesthetics and with the location found in the general public. These two are not exclusive of each other.

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

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