

Original Communication**EVALUATION OF VARIOUS FACIAL ANTHROPOMETRIC PROPORTIONS IN INDIAN AMERICAN WOMEN****Chakravarthy Marx Sadacharan***Department of Anatomy, School of Medicine, American University of Antigua (AUA), Antigua, West Indies***RESUMEN**

El equilibrio y la armonía de los diferentes rasgos de la cara son esenciales para el cirujano quien debe analizar la cara para poder planificar su tratamiento. La evaluación de la cara femenina se puede hacer por medio de medidas lineales, angulares y proporciones. El propósito de esta investigación es examinar varias proporciones faciales en las mujeres aborígenes americanas y compararlas con las normas de las personas indias (de India) y las personas caucásicas. También queríamos saber si estas normas satisfacen las proporciones de oro y de plata. Las medidas faciales antropométricas se tomaron utilizando un calibre digital en cien estudiantes aborígenes americanas (18-30 años) en la Universidad Americana de Antigua (AUA). Un conjunto de proporciones faciales fue calculado y comparado con las normas de las mujeres de la India y de las mujeres caucásicas. Los coeficientes de variación de las proporciones también se calcularon. Todas las proporciones faciales fueron similares con los informes anteriores sobre las mujeres de la India. La mayoría de las proporciones tenían pequeñas coeficientes de variación haciéndolas así muy confiables, debido a la reducción en la variabilidad de las muestras. El índice de altura de la parte superior de la cara, la altura facial mandíbulo-inferior y la altura biocular de la parte superior de la cara se acercaban todos a las proporciones de oro mientras el índice nasal era casi una proporción de plata. Habían diferencias significativas en la mayoría de los resultados cuando se comparaban las estadísticas de los indios y las personas caucásicas utilizando evaluaciones desapareadas. Las estadísticas actuales de las proporciones faciales pueden ser utilizadas como valores de referencia para las mujeres aborígenes de América.

Palabras clave: *Antropometría facial, proporción facial, proporción de oro, proporción de plata.*

ABSTRACT

The balance and harmony of various facial features are essential to surgeon who requires facial analysis in the diagnosis and treatment planning. The evaluation of female face can be made by various linear measurements, angles and ratios. The aim of this study was to investigate various facial ratios in Indian American women and to compare them with the Indian and Caucasian norms. Additionally, we wanted to evaluate whether these values satisfy golden and silver ratios. Direct facial anthropometric measurements were made using a digital caliper in 100 Indian American women students (18 - 30 years) at the American University of Antigua (AUA), Antigua. A set of facial ratios were calculated and compared with Indian and Caucasian norms. Coefficients of variation of the ratios were also calculated. All the facial ratios were found to be similar with previous reports on Indian women. Most of the facial ratios had small coefficients of variation thus making them highly reliable due to reduced intra-sample variability. The upper face-face height index, mandibulo-lower facial height and upper face height-biocular width index were close to golden ratios whereas the nasal index was close to a silver proportion. There was significant difference in most of the values when compared to Indian and Caucasian data using unpaired t test. The present facial ratios data can be used as a reference value for Indian American women.

Keywords: *Facial anthropometry, facial ratio, golden ratio, silver ratio.*

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INTRODUCTION

A face is beautiful and shows harmonious features if the individual components are proportional. This is referred to as facial balance. A pleasant and harmonious face can be a great asset to one's social status. We all have same features in the face. But, their proportions and relationships vary from one face to another within a group or race (George et al, 1993). The facial proportions are essential to facilitate the surgeon who requires facial analysis in the diagnosis and treatment planning.

Anthropometry is an art and science used extensively for measuring the facial soft tissue proportions. Soft tissue plays a major role in determining the outcome of the facial aesthetic surgical procedures (Dunlevy et al, 1987). The Golden ratio, also known as the divine proportion, is considered by many to be the key to the secret of aesthetics, attraction and human beauty (Bashour, 2006).

The Golden ratio (1:1.618) is a special number found by dividing a line into two parts in which, the longer part divided by the smaller part is also equal to the whole length divided by the longer part. It is a geometrical proportion in which, a line AB is divided at a point C in such a way that $AB/AC = AC/CB$. It is often symbolized using phi, after the 21st letter of the Greek alphabet. In 1509, Luca Pacioli wrote a book that refers to the number as the "Divine Proportion," which was illustrated by Leonardo da Vinci. Da Vinci later called this section aurea or the Golden section. The golden ratio was used to achieve balance and beauty in many Renaissance paintings and sculptures. The golden ratio also appears in da Vinci's Vitruvian Man and the Mona Lisa (Baker and Woods, 2001; Rossetti et al, 2013). The silver ratio is an analog of the more well-known golden ratio which arises in many mathematical and geometric expressions. The silver ratio is the limiting ratio of consecutive Pell numbers and is denoted by the symbol δS . The silver ratio is the analogous continued fraction with all coefficients equal to 2.

The scientific applications of golden and silver ratios have been done in various fields like prosthodontics, facial surgery, orthodontics, facial attractiveness study, and in the development of facial mask and dental grid system (Naini and Gill, 2008). Jefferson (2004) stated that, any deviation of human face from golden proportion can result in the development of facial abnormalities and disorders.

A study by Rossetti et al (2013) showed that, the ratios between 3D facial distances were not related to attractiveness and most facial ratios were different from the golden ratio. In recent

years, various studies in the general population and orthodontic patients have tried to establish the importance of golden proportions in determining facial attractiveness and esthetics, but with conflicting results. Certain authors (Jefferson, 2004; Pancherz et al, 2014) found a correlation between golden proportion and facial attractiveness whereas others (Baker and Woods, 2001; Kiekens et al, 2008) failed to find any correlation at all (Rajiv and Juhi, 2014).

Today, orthodontic treatment for facial aesthetic reasons has risen from 25% to over 75%, which means that, 3 out of 4 patients request an improvement of facial appearance (Edler et al, 2006). In Indian population, lower third of face is greater than middle third (Jain et al, 2004). 87.2% of Indian-American adults in 2010 were foreign-born, the highest percentage among the six largest Asian-American groups; 37.6% of those had been in the United States of America (USA). (DeSilver, 2014).

There were very few anthropometric studies that have dealt with different migrant ethnic groups in the USA. Indian Americans are the second-fastest growing ethnic group in the USA. Most of the studies on facial proportion and golden ratio in the USA were done in Caucasians and therefore, may not be applicable for Indian Americans.

Aesthetic surgery on Indian American patients relying on Caucasian norms may result in dissonant facial proportions. It will be useful if facial proportions data for the Indian Americans are maintained and used in case they need to undergo facial surgeries.

A few studies have been conducted on facial proportions in Indian populations, India (Kalha et al, 2008; Packiriswamy et al, 2012; Jagadish Chandra et al, 2012; Upadhyay et al, 2013; Sinojiya et al, 2014; Kalra et al, 2015). A study performed by Husein et al (2010) with 100 Indian American female face by using photographs did not deal with facial proportions. However, there are no reports available on the ear anthropometry in Indian American population.

The aim of the present study was to find out the average values of various anthropometric ratios in Indian American female face and to compare them with the Caucasian norms. This study also attempts to find out if any of the ratios can be called as golden or divine proportions.

MATERIALS AND METHODS

The study group consisted of 100 Indian American female students (with origin to northern India) of American University of Antigua (AUA),

Antigua. The age of the subjects ranged from 18-30 years. This study was approved by AUA ethics committee. The subjects with, previous history of developmental and neurological defects of facial region, cosmetic treatment of facial region, cranio-facial trauma, surgery and bi-racial ethnic origins were excluded. This study was funded by, School of Medicine, AUA, Antigua. The study was explained and the standard informed consent forms were collected from the participants prior to the study. The anthropometric landmarks were identified on the subjects with careful inspection and were marked on the face with black liquid eye liner (Fig. 1).

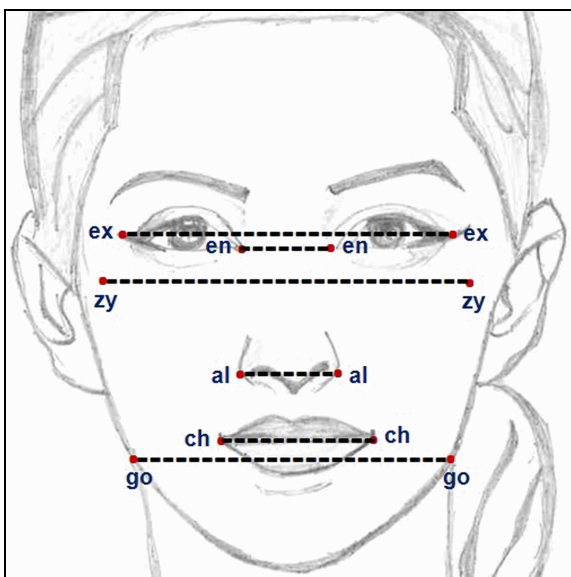


Figure 1: Photograph shows Indian American women facial anthropometric landmarks: en, endocanthion; ex, exocanthion; al, alare; ch, cheilion; go, gonion; zy, zygion.

The following landmarks were made on both sides of the face and measured (Fig. 1 and 2). ex, exocanthion., External commissura of the eye fissure; en, endocanthion., internal commissura of the eye fissure; ch, cheilion., labial commissura; al, alare., most lateral point on the alar contour; sa, superaurale., highest point on the auricle; sb, subaurale., lowest point on the free margin of the auricle; go, gonion., most lateral point on the mandibular angle; zy, zygion., most lateral point of the zygomatic arch. The following landmarks were made along the midline of the face and measured (Fig. 1 and 2). n, nasion., the innermost point between forehead and nose; sn, subnasale., midpoint at the union of the lower border of the nasal septum and the upper lip; st, stomion., midpoint of the horizontal

labial fissure; gn, gnathion., lowest median point on the lower border of the mandible.

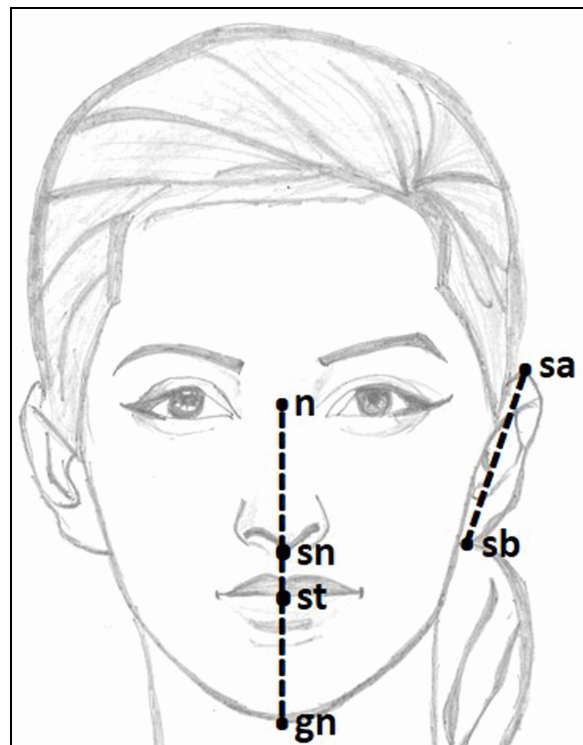


Figure 2: Photograph shows Indian American women facial anthropometric landmarks: n, nasion; st, stomion; gn, gnathion; sn, subnasale; sa, superaurale; sb, subaurale.

Subjects were asked to sit in an upright relaxed position with natural and normal erect posture of the head and shoulders, and both arms hanging free beside the trunk for the linear measurements of the face (Farkas et al, 2005).

Anthropometric measurements (Manual measurement - Direct method) (Packiriswamy et al, 2012): The following measurements were done up to 0.5 degree and 0.5 mm accuracy on the subjects with maximum care and comfort by using Neiko 01407A stainless steel digital caliper with extra-large LCD (liquid crystal display) screen and instant SAE-metric (Society of Automotive Engineers) conversion, New York, USA. Every measurement was obtained twice by the same observer. A third reading was taken in case, if the initial two measurements showed a large discrepancy, and finally the two closer readings out of the three were used.

The following standard linear distances (unit: mm) were measured and compared to find out the average values of ratios in Indian American Women and to compare them with Caucasian

norms. Facial ratios (vertical-vertical, horizontal-horizontal and vertical-horizontal) were undertaken in this study, summarized in Table 1. Data were collected and analyzed in accordance with the current law about personal data and privacy. The statistical analysis was performed using "Graph pad instat" (Version 3.06, Graph pad Software Inc.), San Diego, CA. The paired t

test was used to compare the difference between right and left side linear measurements. Column statistics were used to calculate the mean ratio, standard deviation (SD), minimum, maximum and standard error of mean (SEM). Unpaired t test was done to compare the present study data with other studies using mean, SD and number of samples.

| Table 1: Facial ratios in our study | | | | | | | |
|--|---------------------|-------------|-----------|---------------|-------------|-------------|------------|
| vertical - vertical indices | Ratio | Mean | SD | CV (%) | Min. | Max. | SEM |
| Mandibulo - lower face height | st-gn/sn-gn | 0.67 | 0.04 | 5.94 | 0.59 | 0.75 | 0.0039 |
| Lower face - face height | sn-gn/n-gn | 0.53 | 0.03 | 6.25 | 0.43 | 0.61 | 0.0032 |
| Upper face - face height | n-st/n-gn | 0.63 | 0.05 | 7.77 | 0.54 | 0.82 | 0.0051 |
| Nose - face height index | n-sn/n-gn | 0.45 | 0.04 | 8.61 | 0.32 | 0.54 | 0.0039 |
| Mandibulo - face height | st-gn/n-gn | 0.35 | 0.03 | 8.79 | 0.29 | 0.45 | 0.0031 |
| Ear - lower face height | sa-sb/sn-gn | 0.97 | 0.11 | 11.23 | 0.71 | 1.21 | 0.0108 |
| Ear - nose height | sa-sb/n-sn | 1.13 | 0.14 | 12.35 | 0.82 | 1.51 | 0.0139 |
| Mandibulo - upper face height | st-gn/n-st | 0.57 | 0.07 | 13.03 | 0.4 | 0.82 | 0.0074 |
| Nose - lower face height | n-sn/sn-gn | 0.87 | 0.11 | 13.07 | 0.56 | 1.21 | 0.0113 |
| Upper lip - upper face height | sn-st/n-st | 0.28 | 0.04 | 14.58 | 0.19 | 0.37 | 0.004 |
| Upper lip - nose height index | sn-st/n-sn | 0.38 | 0.07 | 17.91 | 0.26 | 0.57 | 0.0069 |
| Upper lip - mandible height | sn-st/st-gn | 0.49 | 0.09 | 18.31 | 0.33 | 0.71 | 0.009 |
| horizontal - horizontal indices | | | | | | | |
| Mandibular - face width index | go-go/zy-zy | 0.95 | 0.09 | 9.44 | 0.71 | 1.19 | 0.0089 |
| Eye fissure - intercanthal width | en-ex/en-en | 1.14 | 0.12 | 10.19 | 0.91 | 1.5 | 0.0116 |
| Mouth - face width | ch-ch/zy-zy | 0.43 | 0.04 | 10.53 | 0.32 | 0.53 | 0.0045 |
| Eye fissure+intercanthal width - mouth width | (en-ex+en-en)/ch-ch | 1.33 | 0.15 | 10.93 | 1.09 | 1.9 | 0.0146 |
| Eye fissure - nasal width | en-ex/al-al | 0.99 | 0.11 | 11.22 | 0.74 | 1.27 | 0.011 |
| Intercanthal - nasal width | en-en/al-al | 0.87 | 0.1 | 11.31 | 0.65 | 1.21 | 0.0098 |
| vertical - horizontal indices | | | | | | | |
| Upper face height - biocular width index | n-st/ex-ex | 0.68 | 0.06 | 9.3 | 0.56 | 0.81 | 0.0063 |
| Mandibular width - face height index | go-go/n-gn | 1.04 | 0.1 | 9.31 | 0.77 | 1.4 | 0.0097 |
| Facial index | n-gn/zy-zy | 0.92 | 0.09 | 9.66 | 0.74 | 1.09 | 0.0089 |
| Nasal index | al-al/n-sn | 0.75 | 0.08 | 10.76 | 0.56 | 0.95 | 0.008 |
| Upper face index | n-st/zy-zy | 0.57 | 0.07 | 11.44 | 0.44 | 0.75 | 0.0066 |
| Mandibular index | st-gn/go-go | 0.34 | 0.05 | 13.17 | 0.25 | 0.47 | 0.0045 |
| Upper lip height - mouth width index | sn-st/ch-ch | 0.37 | 0.05 | 14.19 | 0.22 | 0.52 | 0.0053 |

Table 1: Facial ratios

RESULTS

The facial anthropometric proportions for 25 indices were calculated in 100 Indian American women and compared with the proportions of Caucasian and Indian women. In this study, the difference between the right and left side linear measurements were not significant; hence the mean values of right and left were taken together. These indices were classified as, vertical to vertical, horizontal to horizontal and vertical to horizontal ratios (Table 1).

The mean, maximum, minimum, coefficient of variation, standard deviation, and standard error of mean were calculated and analyzed (Table 1). Furthermore, these ratios were compared to the Caucasian and Indian women ratios to see if there is any significant difference between them using unpaired t test. The closeness of these ratios to the golden and silver proportion was also analyzed. Some of the parameters have proved to be more similar when compared to others.

In vertical to vertical ratios (Fig. 2), upper face-face height, lower face-face height, mandibulo-facial height, mandibulo-lower facial height and nose-facial height indices have low coefficient of variation (C.V) thus, making them far more reliable as compared to other parameters (Table 1). The coefficient of variation (C.V) has been arranged in ascending order (Table 1).

In vertical to vertical ratios, we had a very high coefficient of variation of upper lip mandible index, upper lip upper face height index and a high upper lip nose height index thus making them far more unreliable as compared to other parameters (Table 1). Other parameters quite reliable include mandibulo upper face height index, ear lower face height index, ear nose height index and nose lower face height index (Table 1).

In horizontal to horizontal ratios (Fig. 1), mandibular face width index was the most reliable parameter with low coefficient of variation. Other parameters such as intercanthal-nasal width, eye fissure intercanthal width, mouth face width, eye fissure intercanthal mouth width and eye fissure nasal width were quite reliable with low coefficient of variation (Table 1).

In horizontal to vertical ratios (Fig. 1 and 2), the following parameters were quite reliable with low coefficient of variation - nasal, upper face height - buccal width, facial, mandibulo width face height, upper face and mandibular. We found a high coefficient of variation of upper lip height mouth width index thus making them far more unreliable as compared to other parameters.

While looking for the golden proportion, it was seen that only upper face to face height index,

mandibulo lower face height index and upper face height to biocular width index had mean values close to the golden proportion. While looking for silver proportion, it was seen that nasal index mean was close to the silver proportion (Table 1).

DISCUSSION

The present study evaluated various facial proportions in vertical and horizontal dimensions of 100 Indian American women using direct anthropometric method in upright posture to establish ideal anthropometric norms.

The anthropometric norms were obtained in order to aid in the objective assessment of esthetics in Indian American women. Comparison of the present study with other studies on Indian and Caucasian women revealed variations and similarities in the facial proportions. The present study also discussed about the closeness of indices to the golden (divine) proportion (0.62) and the silver proportion (0.71) (Ferring and Pancherz, 2008; Kiekens et al, 2008; Jahanbin et al, 2008). In a Japanese painting the concept of silver ratio was introduced (Yanagi, 1967).

In the present study, vertical to vertical facial ratios on Indian American women, mandibulo lower facial height, nose-facial height, mandibulo-facial height, upper lip upper face height, upper lip nose height and upper lip mandible height indices were similar with previous studies done on Indian women (Kalra et al, 2015; Jagadish Chandra et al, 2012; Farkas, 1994) and North American White women (Farkas and Cheung, 1979).

The lower face-face height (Kalra et al, 2015; Jagadish Chandra et al, 2012) mandibulo upper facial height (Kalra et al, 2015) and upper face-face height (Kalra et al, 2015; Farkas, 1994) indices in Indian women studies were also in agreement with present study whereas, North American White women (Farkas and Cheung, 1979) study showed statistically significant difference ($p < 0.001$). In the available literature search, I could not find the data on ear lower face index, ear nose height index and nose lower face height index for the comparison.

In the present study, the upper face-face height, lower face-face height, mandibulo-facial height, mandibulo-lower facial height and nose-facial height indices had low coefficient of variation and more reliable for judging the facial esthetics when compared to upper lip mandible index, upper lip upper face height index and upper lip nose height index showed a high coefficient of variation thus making them lesser reliable. The upper lip upper

face height index showed low coefficient of variation (7%) in Indian women (Kalra et al, 2015) and high coefficient of variation (14.58%) in the present Indian American women study.

In the present study, the means of mandibulo lower face height index (0.67) and upper face to face height index (0.63) were close to the golden proportions which are similar to the previous studies on Indian women (0.65; 0.69) (Kalra et al, 2015) and Caucasian women (0.61; 0.69) (Farkas, 1994) respectively.

In horizontal to horizontal facial ratios on Indian American women, mouth face width index was similar with previous studies done on Indian women (Kalra et al, 2015; Jagadish Chandra et al, 2012; Farkas, 1994) and North American White women (Farkas and Cheung, 1979). The mandibular face width (Jagadish Chandra et al, 2012) and intercanthal nasal width (Kalra et al, 2015; Jagadish Chandra et al, 2012) indices in Indian women studies were also similar with present study whereas, North American White women (Farkas and Cheung, 1979) and Indian women (Farkas, 1994) studies showed statistically significant difference ($p < 0.001$). In the available literature search, I could not find the data on eye fissure intercanthal width, eye fissure nasal width and eye fissure intercanthal mouth width indices for the comparison.

In the present study, mandibular face width index has low coefficient of variation (9.44%) and more reliable for judging the facial esthetics when compared to other horizontal to horizontal ratios. In the present study, mouth face width index showed low coefficient of variation (7%) and was similar to a study conducted by Kalra et al (2015). In the present study, the means of horizontal to horizontal ratios were not close to the golden proportion. The mean of nose mouth width index in Indian women (0.69) by Kalra et al (2015) and in Caucasian women (0.63) by Farkas (1994) showed close to the golden proportion.

In vertical to horizontal facial ratios on Indian American women, upper face index was similar with previous studies done on Indian women (Kalra et al, 2015; Farkas, 1994). The upper face height biocular width (Kalra et al, 2015), mandibular width face height (Kalra et al, 2015), facial (Farkas and Cheung, 1979; Farkas, 1994), mandibular (Kalra et al, 2015) and upper lip height mouth width (Kalra et al, 2015; Farkas and Cheung, 1979; Farkas, 1994) indices in Indian women studies were also similar with the present study whereas, North American White women (Farkas and Cheung, 1979) and Indian women (Jagadish Chandra et al, 2012) studies showed statistically significant difference ($p < 0.001$). Nasal index was not in agreement with previous studies done on Indian women (Kalra et al, 2015;

Jagadish Chandra et al, 2012; Farkas, 1994) and North American White women (Farkas and Cheung, 1979).

In the present study, upper face height biocular width, mandibular width face height and facial indices had low coefficient of variation and more reliable for judging the facial esthetics when compared to upper lip height mouth width index showed a high coefficient of variation. In the present study, the upper face index showed low coefficient of variation (11%) and reliable when compared to a study conducted by Kalra et al (2015).

In the present study, the mean of upper face height-biocular width index (0.68) was close to the golden proportion and nasal index (0.75) was close to the silver proportion. The mean of nasal index in Indian women (0.62) (Kalra et al, 2015) and in Caucasian women (0.64) (Farkas, 1994) showed close to the golden proportions.

Variations in the facial morphology arise through number of factors which include gender, race, dietary, climate, and environment where we live (Wankhede et al, 2012). The climate, dietary, and environment are different in USA when compared to India. Kunjur et al (2006) suggested that the aesthetic standards of a particular group may not suit other patients belonging to diverse racial and ethnic background.

The evaluation of ideal ratios rather than actual measurements is better since it is the proportion that matters for judging the esthetic value of a subject whether living or nonliving rather than the actual measurements. The ratios nullify the errors in measuring the linear distances on photographs (Kalra et al, 2015). The studies done on Indians (Kalha et al, 2008; Packiriswamy et al, 2012; Jagadish Chandra et al, 2012; Upadhyay et al, 2013; Sinojiya et al, 2014; Kalra et al, 2015) were based on photographic data.

Results of certain facial ratios in the present study differ from previous reports in Indian women which may be due to differences in the method of measurement used and diverse ethnic background of the our study subjects from within India.

All the 25 variables were found to be similar. Three variables namely upper face-face height index, mandibulo-lower facial height and upper face height-biocular width index were close to golden proportions whereas nasal index was close to silver proportion.

The present study's facial ratios data can be used as a reference value for Indian American women which can be made use of if they need to undergo facial surgery. The aesthetic surgeons must know the average and ideal facial proportions when they apply to the Indian American women patients so that surgical

procedures can be performed with the goal in mind of achieving an attractive and harmonious appearance.

Conflict of Interest

None

Funding

This study was funded by the School of Medicine, American University of Antigua (AUA), Antigua, West Indies.

Ethical Approval

This study was approved by AUA ethics committee.

Informed Consent

The standard informed consents were collected from the participants prior to the study

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