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Anthropometric study using craniofacial features to determine gender in Lucknow population

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Abstract

Background: Gender is one of the main characteristics analyzed for positive human identification in forensic medicine. The methods involving physical anthropology present high rate of accuracy for human identification and gender estimation. **Aim:** This study aimed to determine gender through different craniofacial variables using physical anthropometric methods. **Materials and Methods:** A cross-sectional study was conducted among 100 individuals (50 males and 50 females) in Lucknow. Variables studied through physical anthropometry in both the genders were facial height, nasion-to-menton distance, interzygomatic arch width, and intercanthal width using a digital sliding caliper. All the measurements were taken twice. The final value was the average of the two obtained values. **Results:** Comparing the mean craniofacial features between two genders, *t*-test revealed significantly higher facial height, pronasale-to-menton distance, and interzygomatic width in males as compared to females, but the mean intercanthal width was found to be the same. Pearson's correlation analysis revealed a positive correlation between facial height and pronasale-to-menton distance, facial height and interzygomatic width, pronasale-to-menton distance and interzygomatic width, and interzygomatic width and intercanthal width. **Conclusion:** The craniofacial features may serve as diagnostic markers for gender identification and can be used interchangeably.

Key words: Facial height, gender estimation, intercanthal width, interzygomatic width, physical anthropometry

Introduction

Forensic anthropology is the practical application of a knowledge of general anthropology to law, especially in questions related to the medicolegal identity, police identity, and human research of forensic dentistry and forensic medicine.[1]`

In cases of determination of human identity, gender is one of the most important characteristics assessed. This

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investigation is necessary for dead bodies, because it allows the detection of the total number of individuals during mass disasters or *in vivo* cases, for situations of intersexuality, pseudohermaphroditism, rape, investigation of maternity/paternity, etc.[2] Anthropological patterns have been investigated in different regions around the world for human identification.[3] Methods involving physical anthropology present high rate of accuracy for human identification and gender estimation.[4]

To the best of our knowledge, no such study has been done among Lucknow population, so with the background in concern of forensic anthropology, this study was undertaken using anthropometric data.

Materials and Methods

An institutional based cross-sectional study with some analytical components was conducted in Babu Banarasi Das College of Dental Sciences, Lucknow, Uttar Pradesh, India. The study group included 50 males and 50 females of 30 to 40 year age group belonging to Lucknow. The above-mentioned age group was considered, because after puberty, the amount of craniofacial growth decreases steadily and almost ceases after the second decade of life. Individuals of mixed origin and with a history of congenital craniofacial anomaly, with major craniofacial trauma and orthodontic treatment, and who have undergone craniofacial reconstructive surgery or having craniofacial deformities or irregular dentition were excluded from the study. Variables studied through physical anthropometry in both the genders were facial height, pronasale-to-menton distance, interzygomatic arch width, and intercanthal width.

All the physical measurements were taken using a digital sliding caliper after each individual was asked to maintain a neutral, relaxed facial expression without lifting the head and to breathe calmly through their nose. Facial height measurement was derived as the distance from nasion to menton as shown in Figure 1a and b. The measurements of the intercanthal distance are taken between the medial canthi of the eye as shown in Figure 1c and d. Figure 2a and b depicts the interzygomatic distance, and the measurement of the pronasale-to-menton distance using a digital sliding caliper is depicted in Figure 2c and d. All the measurements were taken twice to control the measurement error, and the average of the aforementioned values was used for the study.

Results

The craniofacial features/measurements (facial height, pronasale-to-menton distance, interzygomatic width, and intercanthal width) were summarized as mean ± standard error (SE of the mean). The craniofacial measurements between males and females were compared by independent Student's *t*-test. Pearson's correlation analysis was done to assess the association between measurements. Intraobserver reliability of the measurements was compared by paired *t*-test and intraclass correlation coefficient (ICC) analysis. A two-tailed (α = 2) $P < 0.05$ was considered statistically significant.

Interobserver reliability

To assess the reliability of craniofacial measurements (facial height, pronasale-to-menton distance, interzygomatic width, and intercanthal width), the measurements assessed by observer 1 were reassessed by another independent observer 2 within 1 week in random order and compared by paired *t*-test and ICC analysis and are summarized in Table 1. Table 1 shows the insignificant ($P > 0.05$) mean difference in the measurements with minimum error (SE < 1.00) and high ICC (0.622–0.997) indicating high reliability of craniofacial measurements. The values observed by observer 1 were submitted for statistical analyses.

Craniofacial measurements between males and females

The difference in craniofacial measurements between males and females is summarized in Table 2 and also depicted in Figure 3. Comparing the mean craniofacial measurements between two genders, *t*-test revealed significantly ($P < 0.01$ or $P < 0.001$) different and higher facial height,

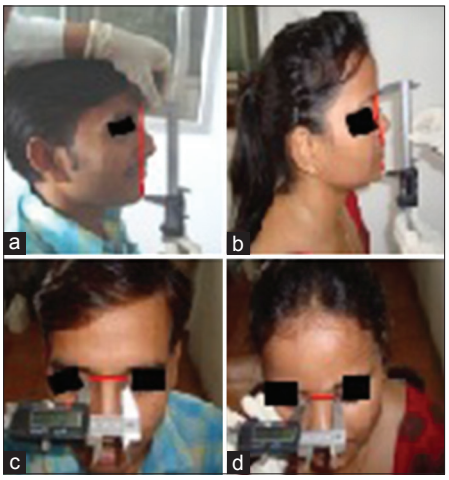

Figure 1: (a and b) Facial height measurement from nasion to menton; (c and d) intercanthal distance

Table 1: Interobserver reliability of craniofacial measurements (*n*=100)

Craniofacial measurements (mm)	Mean±SE		ICC value	*t*	*P*
	Observer 1	Observer 2			
Facial height	107.12±0.74	107.40±0.75	0.997	0.35	0.725
Pronasale-to-menton distance	67.59±0.67	67.52±0.71	0.863	0.21	0.833
Interzygomatic width	97.96±0.60	97.63±0.54	0.622	0.67	0.502
Intercanthal width	29.95±0.30	29.90±0.31	0.916	0.42	0.679

SE: Standard error, ICC: Intraclass correlation coefficient

pronasale-to-menton distance, and interzygomatic width in males as compared to females. However, the mean intercanthal width did not statistically differ ($P > 0.05$) between the two genders.

Correlation

To find out that these craniofacial features can be used interchangeably, intercorrelation (association) was done between craniofacial features and is summarized in Table 3. Pearson's correlation analysis revealed a significant and positive (direct) correlation between facial height and pronasale–to-menton distance ($r = 0.83$, $P < 0.001$) [Figure 4], facial height and interzygomatic width ($r = 0.30$, $P < 0.01$) [Figure 5], pronasale-to-menton distance and interzygomatic width ($r = 0.22$, $P < 0.05$), and interzygomatic width and intercanthal width ($r = 0.25$, $P < 0.05$).

This high correlation was especially found between facial height and pronasale-to-menton distance and facial height and interzygomatic width.

Figure 2: (a and b) Interzygomatic distance; (c and d) pronasale-to-menton distance

Discussion

Determination of sex is an important concern to the forensic anthropologist as it is critical for individual identification.

Table 2: The craniofacial measurements (mean±standard error) between males and females

Craniofacial measurements (mm)	Females ($n=50$)	Males ($n=50$)	t (df=98)	P
Facial height	102.15±0.76	112.10±0.80	9.00	<0.001
Pronasale-to-menton distance	62.95±0.61	72.24±0.75	9.61	<0.001
Interzygomatic width	96.10±0.82	99.83±0.80	3.25	0.002
Intercanthal width	29.80±0.41	30.10±0.43	0.50	0.621

SE: Standard error

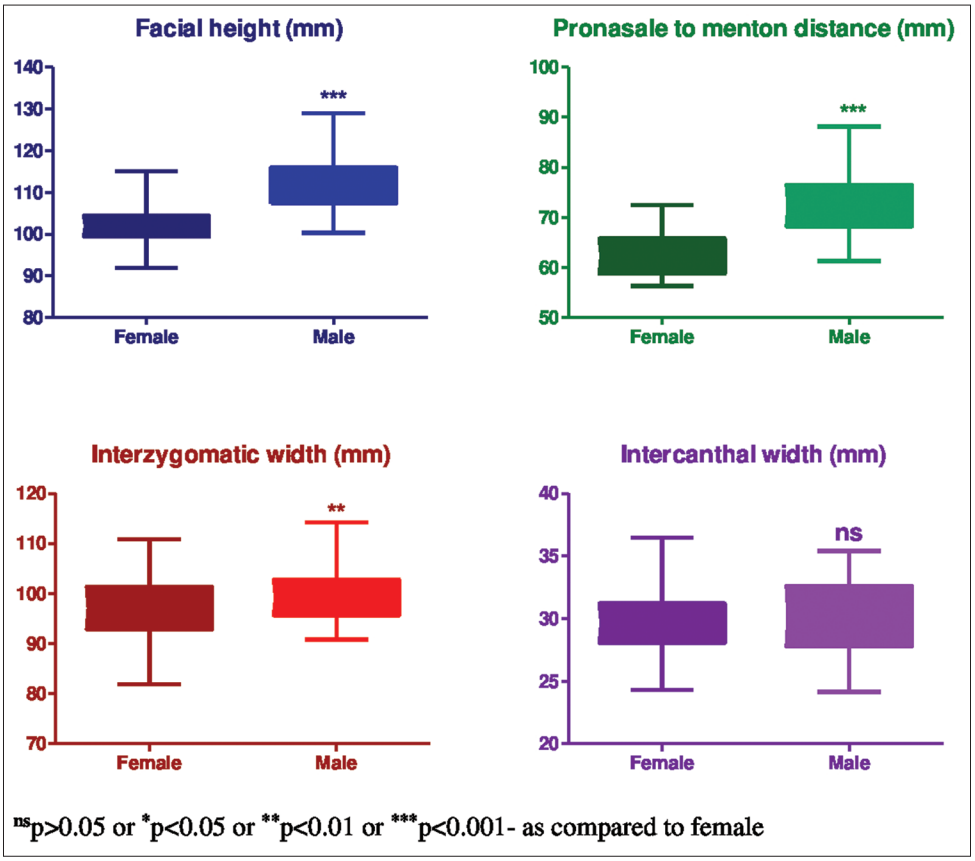

Figure 3: Comparison of craniofacial measurements between two genders

Table 3: Inter correlation between craniofacial measurements (n=100)

Craniofacial measurements (mm)	Facial height	Pronasale -to -menton distance	Interzygomatic width	Intercanthal width
Facial height	1.00			
Pronasale -to- menton distance	0.83***	1.00		
Interzygomatic width	0.30**	0.22*	1.00	
Intercanthal width	0.03 (NS)	0.05 (NS)	0.25*	1.00

NS - P>0.05, *P<0.05, **P<0.01, ***P<0.001. NS: Not significant

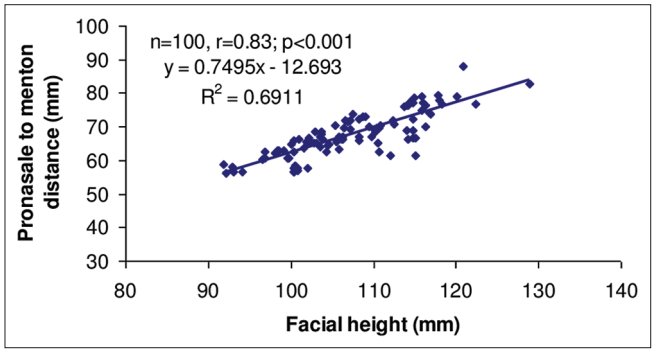

Figure 4: Correlation between facial height and pronasale-to-menton distance

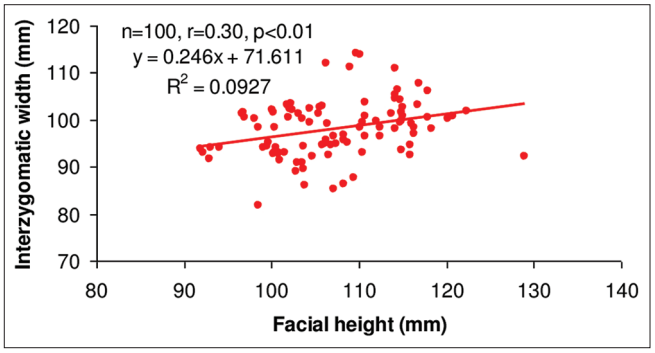

Figure 5: Correlation between facial height and interzygomatic width

The anthropometric study using craniofacial features is probably the most important in this context.[5]

In the field of forensic medicine, normally the available materials after sufficiently long period of death are utilized to determine various body characteristics such as age and sex for identification of an individual. Gender has long been determined from skull, pelvis, and the long bones with epiphysis and metaphysis in unknown skeletons. The use of anthropometry may arise under several circumstances, i.e., natural, intentional, and accidental (air crash, train accidents, flood, fire, etc.). The gender of an individual can be identified accurately in 80% of cases using skull alone and 98% cases using pelvis and skull together.[6]

Apart from this, the anthropometry of face is important in formulating standard sizes while planning facial surgeries and designing of the facial equipment. Akinbami and Mark Ikpeama demonstrated that genetic, environmental, and hormonal factors play a significant role in growth discrepancies.[7] There are significant differences in hormonal levels at different stages of life, and with such changes, there may be corresponding changes in anthropometric craniofacial parameters. Bazmi and Zahir stated that facial anthropometry is a direct means of facial measurement that uses standard landmarks and instrumentation to compare populations.[8]

In the present study, we observed significantly increased (P < 0.001) facial height with a mean ± standard deviation (SD) of 112.10 ± 5.66 mm in males and 102.15 ± 5.40 mm in females. Our findings are in accordance with the findings of Joy *et al*. They reported a higher facial height with a mean ± SD of 12.25 ± 2.11 cm in males and 11.19 ± 1.92 cm in females of Igbo ethnic origin.[9] In their study, they also stated that during maturity, there is a natural increase in the cartilaginous tissue of the face causing an increase in certain facial parameters. According to their study, the sexual difference is better projected as one attains adulthood.[9] According to Joy *et al*., the facial height used to determine sexual dimorphism was significantly higher in males (12.25 cm) compared to females (11.19 cm) of Igbo ethnic group among Nigerians with P < 0.05.[9] Similar findings were reported by Anibor *et al*. in the age group between 18 and 30 years. They observed that the mean facial height was 11.58 cm in Ijaw males and 10.86 cm in Ijaw females.[10]

In the present study, the interzygomatic arch width was significantly higher in males (99.83 ± 5.64 mm) as compared to females (96.10 ± 5.83 mm) with P = 0.002. The findings of the present study are in accordance with the findings of Kasaab who reported the interzygomatic distance in males to be 120.90 ± 6.4 mm, and in females, it was less and was found to be 110.35 ± 5.9 mm, in their study among dental students of University of Mosul.[11]

Agarwal *et al*. stated that the face can be reconstructed (identifying the dead), superimposed, or compared to facial photographs (mistaken identities or missing persons) based on the dysmorphic characters using anthropological measurements. the diagnosis of many dysmorphic syndromes is based on advanced cytogenetic and molecular techniques. orbitofacial anthropometrics have become an important tool used by a genetic counselor and reconstructive surgeons.[12] in the present study, the mean intercanthal width did not differ (p > 0.05) between the two genders. the mean ± sd was observed to be 30.10 ± 3.06 mm

in males and 29.80 ± 2.87 mm in females. our findings were similar to the study done by agarwal *et al*. who reported the intercanthal width in the age group above 25–40 years; the mean ± sd was 32.50 ± 2.82 mm in males and 32.00 ± 2.67 mm in females among the residents of chhattisgarh region.[12] the results of our findings are in contrast to the study done by oladipo *et al*. who reported that the intercanthal distance was significantly higher in males (3.40 ± 0.14 cm) as compared to females (3.00 ± 0.39 cm) among nigerians.[13] younger population tends to have lower values of intercanthal distance in comparison to older population, and the canthal measurements became constant in the third decade of life. this was in accordance with fledelius and stubgaard and pryor.[14,15]

In the present study, pronasale-to-menton distance was significantly higher in males (72.24 ± 5.32 mm) as compared to females (62.95 ± 4.29 mm) with $P < 0.001$. To the best of our knowledge, no such study comparing the pronasale-to-menton distance has been done. Hence, we included this parameter in our study to assess the alterations in the middle third of the face and protrusion of menton region. Further, a significant and high correlation was found in our study, especially between facial height and pronasale-to-menton distance ($r = 0.83$, $P < 0.001$) and facial height and interzygomatic width ($r = 0.30$, $P < 0.01$), indicating that these craniofacial features can also be used interchangeably.

Conclusion

The craniofacial features may serve as diagnostic markers to discriminate male and female genders and can also be used interchangeably. In the present study, we assessed four parameters though it is not necessary to use all of them to differentiate the genders. Our study depicted significant variation in measurements when both the genders were compared though the intercanthal distance showed minimal variation. Difference of 2–3 mm can be appreciable when measurements are carried out in dry skull which reiterates the role of soft tissue in the same. There are various parameters to determine gender, but physical anthropometry will guide us to determine the gender of unidentified skull remains. The present study concludes that the physical anthropometry of Lucknow population with larger sample size will give a standard and concrete range of measurements to decipher unidentified remains of this locality.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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