Original Article

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Study of Upper Facial Index in Adult Indian Skulls

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Abstract

Introduction: Identification of a deceased person is of utmost importance from social and medicolegal viewpoint. Skull is the second most preferred bone after pelvis for identification of sex of the deceased as it is highly dimorphic and craniometry is highly objective and reproducible. Craniometric indices show the relationship between different dimensions and are crucial for classification of race and sex of unknown skeletons. Several studies have been conducted on various craniometric indices**.** Upper facial index is the percentage ratio of upper facial height to facial width. Recently it has been proposed as a novel index for sexual dimorphism but its status as a sexually dimorphic trait has not yet been well established and is questioned by a few studies. Hence to evaluate the sexual dimorphism of upper facial index and to provide population specific data on facial morphometry, this study was performed on adult Indian skulls. *Methods:* The study was performed on 100 adult Indian skulls (60 male and 40 female) of known age and sex. Parameters measured were upper facial height and bizygomatic breadth using sliding and spreading calliper. Upper facial index was calculated. These parameters were expressed in descriptive statistics i.e. mean, range and standard deviation and the difference of their means between male and female skulls was compared for significance using the Student t-test. Results were compared with available literature. *Results:* In the present study, mean upper facial height (nasion-prosthion height) in male and female skulls was 61.71±3.65mm and 56.49±3.15mm respectively while bizygomatic breadth (maximum bizygomatic diameter) was 127.63±4.79mm and 121.33±4.28mm respectively. Student's t test shows the difference of their means between male and female skulls to be statistically highly significant. The mean upper facial index was 48.36±2.52 in male, while it was 46.60±2.72 in female skulls placing most of the skulls in euryene (broad face) category with a few female skulls in hypereuryene (very broad face) and a few male skulls in mesene (round face) category. The difference of means of upper facial index between male and female skulls was also statistically significant. *Conclusion:* This study ascertains that the upper facial height, bizygomatic breadth and upper facial index are statistically significant sexually dimorphic traits which can be used for sexual dimorphism of adult Indian skulls. The facial morphometric data provided by this study will be helpful in anthropology and forensic medicine for evaluation of race and sex as well as in facial reconstruction surgeries, evaluation of facial trauma and congenital anomalies.

Keywords: Upper facial height; Nasion-prosthion height; Bizygomatic breadth; Upper facial index; Sexual dimorphism; Skull.

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Introduction

Identification of a deceased individual has social, economic and legal implications. Various natural and accidental circumstances may necessitate the use of anthropometry to identify the deceased person [1]. To establish the identity of the deceased from bones is most important for anatomist, forensic experts and anthropologist. One of the main features considered in skeletal analysis for identification

purposes is the sex. Almost all bones of the human skeleton show some degree of sexual dimorphism [2]. Skull is the most dimorphic for identification of sex of skeleton after pelvis, with high accuracy up to 94% [1]. Metric studies of the skull have been considered most reliable owing to their objectivity, reproducibility and statistical value [3]. Sex determination by metric traits of cranial structures has been tested by many authors around the world [3].

Craniometric indices show the relationship between different dimensions (length and breadth) which can be expressed as ratios or percentages of comparison of two measurements. The general formula of index is the ratio of numerator (smaller measurement) to denominator (larger measurement) multiplied by hundred [4]. They are crucial for classification of race and sex of individuals of unknown identity [5-7]. Several researches have worked on various craniometric indices [5].

Upper facial index is one of the indices used in craniometry [8]. It is calculated by dividing the upper facial height (nasion-prosthion height) by bizygomatic breadth and multiplying the quotient by 100. Recently, this index has been proposed as a novel sexually dimorphic measure, with men suggested to have higher values than women. However, not all studies have observed this dimorphism and the status of upper facial index as a sexually dimorphic trait is unclear and has not yet been well established [9]. Hence one of the aims of this study was to evaluate the sexual dimorphism of upper facial index among adult Indian skulls.

Shape of the head and face depends on many factors, such as gender, race and ethnicity, climate, socio-economic, nutritional, and genetic factors and certain pathological conditions [10,11]. Knowledge of facial measurements is valuable for evaluation of race, sex and stature as well as in maxillofacial surgeries [10,12]. It is also helpful in evaluation of facial trauma and identification of certain congenital malformations and for studying growth trends and in orthodontics [10,13]. Various researchers have done studies on facial morphometry to establish standardized mean values for skeletal, dental and soft tissue structures as well as for classification of facial morphology of different populations [14]. The population variation and changes with time in skeletal morphology necessitates the development and updating of population-specific osteometric standards [15]. However, a very few studies have been done in India on these facial measurements with respect to population and environment [12]. Hence another aim of this study was to provide population specific data on facial morphometry which will be helpful to anatomists, anthropologists, forensic scientists and maxillo-facial surgeons.

Material and Methods

The study was conducted on 100 adult skulls of known sex (60 male and 40 female) available in the anatomy department. Measurements were taken after putting the skull in Frankfurt's horizontal plane. Instruments used for the measurement were marker, sliding calliper and spreading calliper. All the measurements were taken thrice and their average was recorded in milimeter.

Only dry, ossified and intact adult skulls free of any deformity or artefacts were included in the study.

Craniometric landmarks were located [4,16-20] as shown in Figure 1 and following parameters were recorded in all the skulls-

1. Upper facial Height (Nasion-Prosthion Height) –vertical distance from *nasion* to *prosthion* [*Nasion, N*- point of intersection of internasal suture and frontonasal suture in the midsagittal plane *Prosthion, P*- The most anterior point on the maxillary alveolar process in the midline between the central incisor teeth]
2. Bizygomatic breadth (width or diameter) — the

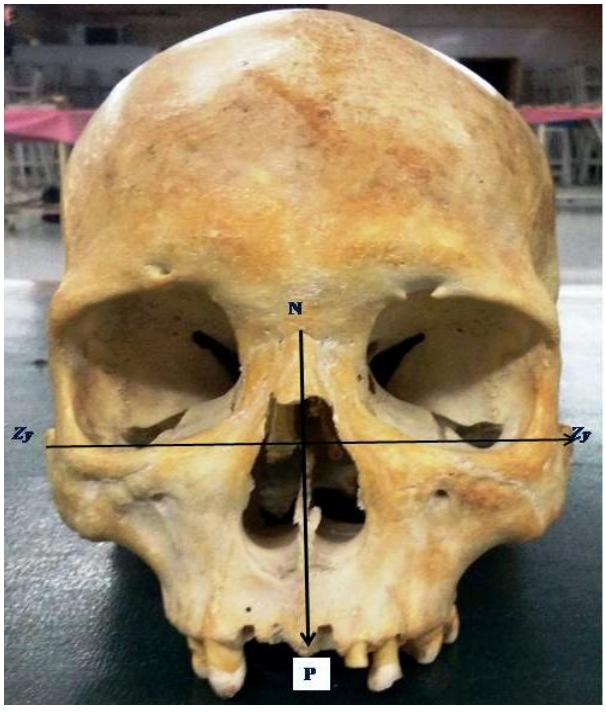

Fig. 1: Measurement of uper facial (Nasion N. to prosthion P. height) and Bizygomatic breadth (Zygion, Zy to Zygion, Zy)

greatest horizontal distance between most lateral points on two zygomatic arches (*Zygion, Zy*- Most lateral point on the zygomatic arch)

3. Upper Facial Index - Calculated as upper facial height (Nasion-Prosthion Height)X100/ Maximum bizygomatic breadth

All the measurements were recorded in millimetre and were tabulated. The Upper facial index was calculated for each skull. The descriptive statistics i.e. mean, SD and Range were calculated for each parameter. The means of various parameters of male and female skulls were compared for significance using the Student t-test. Confidence interval of 95% was assumed and the differences were considered significant at $P \leq 0.05$ and highly significant at $P \leq 0.001$.

Results

The range, mean and standard deviation (S.D.) of upper facial height (Nasion-Prosthion height), bizygomatic breadth and upper facial index of all skulls are presented in Table-1. In the present study, mean nasion-prosthion height in male and female skulls was 61.71±3.65mm and 56.49±3.15mm respectively while bizygomatic breadth was 127.63±4.79mm and 121.33±4.28mm respectively. In male skulls the mean upper facial index was 48.36±2.52, while it was 46.60±2.72 in female skulls. For all the parameters, 'p' values indicated statistically significant differences between mean values of male and female skulls. Male values were always higher than females. There was statistically

Table 1: Descriptive Statistics and p value of Upper Facial Index in Male and Female Skulls

		Upper Facial Height (Nasion-Prosthion Height) in mm	Bizygomatic Breadth in mm	Upper Facial Index
Male	Range	52.5 – 68.5	117 – 138	42.00 – 57.09
	Mean	61.71	127.63	48.36
	SD	3.65	4.79	2.52
Female	Range	52.2 – 66.6	115 – 130	40.78 – 54.15
	Mean	56.49	121.33	46.60
	SD	3.15	4.28	2.72
	P value (Difference of Mean)	**P<0.001 (Highly Significant)**	**P<0.001 (Highly Significant)**	**P<0.05 (Significant)**

Table 2 (i): Facial types by Upper Facial Index in Male and Female skulls according to Banister's [6] classification and El-Najjar [18] classification

Facial type	Upper Facial Index range	Total no. of skulls	No. of Male skulls	No. of Female skulls
Hypereuryene (very broad face)	<45	13	5	8
Euryene (broad face)	45-49.9	67	40	27
Mesene (round face)	50-54.9	19	14	5
Leptene (long face)	55-59.9	1	1	0
Hyperleptene (Very long face)	≥60	0	0	0

Table 2 (ii): Facial types by Upper Facial Index in Male and Female skulls according to Martin and Saller[4] classification

Facial type	Upper Facial Index range	Total no. of skulls	No. of Male skulls	No. of Female skulls
Hypereuryene (very broad face)	<43	4	2	2
Euryene (broad face)	43-47.9	53	25	28
Mesene (round face)	48-52.9	40	31	9
Leptene (long face)	53-56.9	2	1	1
Hypeleptene (very long face)	≥57	1	1	0

significant difference of means of upper facial height (nasion-prosthion height), bizygomatic breadth and upper facial index between male and female skulls.

Based on upper facial index, the types of facial shapes were categorised according to Banister's [6] classification (which is same as that of El-Najjar [18] classification) as shown in Table 2 (i). According to this classification, 67% of the skulls in the present study were Euryene (broad faces), with few skulls

falling under Hypereuryene (very broad face-13%) and Mesene (round face-19%) category. Only one skull in Leptene (long face) and no skull in Hyperleptene (very long faces) category were observed.

Based on Martin and Saller [4] classification of upper facial index, the types of facial shapes were categorised as shown in Table-2 (ii). According to this classification, 53% of the skulls in the present study were Euryene (broad faces) and 40% were Mesene (round face). Male skulls were almost equally distributed among these two categories, while female skulls were mostly Euryene. Very few skulls were falling under Hypereuryene (very broad face-4%) category. Only two skulls in Leptene (long face) and one in Hyperleptene (very long faces) category were observed.

Discussion

Skull is the skeleton of the head and consists of cranial vault and facial skeleton. The facial skeleton consists of maxillae, zygomatic, nasal, lacrimal, palatine, vomer, inferior nasal conchae and mandible bones [6]. The shape of the face is determined by underlying bone, thickness and distribution of the underlying fat as well as the facial muscles [21]. The facial framework is expressed as the facial index, which is the ratio of facial length to facial width [22]. Recently, upper facial index (the percentage ratio of upper facial height to bizygomatic breadth) has been proposed for sexual dimorphism, with men suggested to have a higher index than women. However, not all studies have observed this dimorphism and the status of upper facial index as a sexually dimorphic trait is unclear and has not yet been well established [9]. Hence to evaluate the sexual dimorphism of upper facial index among adult Indian skulls, this study was performed.

Anthropometric studies are an integral part of craniofacial surgery and syndromology. For these reasons, standards based on ethnic or racial data are desirable because these standards reflect the potentially different patterns of craniofacial growth resulting from racial, ethnic, and sexual differences [23]. This study was thus also aimed to provide population specific data on facial morphometry which would be of help in anthropology and forensic medicine for evaluation of race and sex as well as in facial reconstruction surgeries, in evaluation of facial trauma and identification of certain congenital malformations [10,12].

Upper facial height (Nasion-Prosthion height)

Upper facial height (Nasion-Prosthion height) is the vertical distance from *nasion*- the point of intersection of internasal suture and frontonasal suture in the midsagittal plane to *prosthion* - the most anterior point on the maxillary alveolar process in the midline between the central incisor teeth. The upper facial height in the present study was 61.71±3.65mm in male and 56.49±3.15mm in female skulls with statistically significant difference (Table 1). These results corroborates with previous studies conducted among different populations in which the upper facial height was found to be significantly higher for the male crania than for the female crania (Table 3)[15,24-26]. However, one study by Vidya et al (2012)[25] on 80 south Indian skulls observed that though the upper facial height was higher in males than females, the difference was not significant statistically [25].

Our results agree with previous studies which reported that most human craniofacial measurements, in particular the linear ones, show statistically significant sex differences and male skulls are 8.5 % larger than female skulls [27-28].

Higher upper facial height observed in North Indian and Thai skulls indicate that these

Table 3: Comparison of means of Upper Facial Height of Male and Female skulls

Sr. No.	Name and year of the study	Study Sample	Male	Female	Study population	Mean Upper facial height (in mm) Males	Mean Upper facial height (in mm) Female	Significance (p Value)
1	Present Study (2017)	100 Skulls	60	40	Indian	61.71	56.49	P<0.001 HS
2	Zaki et al. (2012)[24]	Xrays of ancient 149 skulls of Greco-Roman period	90	59	Bahriyah oasis	57.90	55.58	P=0.004 S
3	Vidya et al. (2012)[25]	80 skulls	41	39	South Indian	60.9	60.2	P=0.516 NS
4	Sangvichien et al. (2007)[26]	101 Skulls	66	35	Thai	67.12	62.14	P<0.001 HS
5	Saini R and Saini V (2016)[15]	483 Skulls	316	167	North Indian	65.89	61.47	P<0.001 HS

populations have longer faces than the study population [15,26]. This difference may have been caused by environmental factors (geographical variations) or food habits, which may have led to an increased size of the maxillary alveolar arch.

Bizygomatic Breadth

Bizygomatic breadth (width) or maximum bizygomatic diameter is the greatest horizontal distance between most lateral points on two zygomatic arches (*Zygion).* In the present study, the mean bizygomatic breadth in male skulls was 127.63±4.79mm and in female skulls was 121.33±4.28mm with statistically significant difference (Table 1). These results corroborates with most of the previous studies conducted among different populations in which the bizygomatic breadth was found to be significantly higher for the male crania than for the female crania (Table 4) [2,3,10,15,24-26,29]. Study by Osvaldo et al. (2012) [3] on nine variables, using discriminant analysis stepwise model, showed that the bizygomatic breadth presented the greatest sexual dimorphism ($p < 0.001$). The study by Saini R and Saini V (2016) [15] to identify sexual dimorphism of 21 craniofacial measurements for adult male and female samples from North India observed the bizygomatic breadth as the most sexually dimorphic feature with highest sex classification accuracy of 82.2. Thus our result is in support with the antecedent studies exhibiting a consistent sexual dimorphism in bizygomatic breadth in the populations of different geographical regions [1-3]. However, a study conducted on 80 south Indian skulls by Vidya et al (2012) [25] found that though the mean bizygomatic breadth was higher in males than females, the difference was not significant statistically. This may be due to the small sample size of the study.

Table 4: Comparison of means of Bizygomatic Breadth of Male and Female skulls

Sr. No.	Name and year of the study	Study Sample (No. of skulls)	Male	Female	Study population	Mean Bizygomatic Breadth (in mm) Males	Mean Bizygomatic Breadth (in mm) Female	Significance (p Value)
1	Present Study (2017)	100 Skulls	60	40	Indian	127.63	121.33	P<0.001 HS
2	Osvaldo et al. (2012)[3]	100 Skulls	50	50	Brazilian	110.88	103.29	P<0.001 HS
3	Jeremić et al. (2013)[10]	700 persons	360	340	Serbian	129.12	119.98	P<0.001 HS
4	Zaki et al. (2012)[24]	Xrays of ancient 149 skulls of Greco-Roman period	90	59	Bahriyah oasis	16.434	15.745	P<0.001 HS
5	Vidya et al. (2012)[25]	80 skulls	41	39	South Indian	127.3	126.1	P=0.732 NS
6	Mahakkanukrauh et al. (2015)[29]	200 Skulls	100	100	Thai	133.81	124.72	P<0.001 HS
7	Sangvichien et al. (2007)[26]	101 Skulls	66	35	Thai	136.33	127.54	P<0.001 HS
8	Deshmukh and Devershi (2006)[2]	74 skulls	40	34	Indian	126	121	P<0.001 HS
9	Saini R and Saini V (2016)[15]	483 Skulls	316	167	North Indian	125.07	116.86	P<0.001 HS

The greater bizygomatic breadth in males may be due to the extra curving of the zygomatic arch which is a reflection of more preponderant male robusticity and large masticatory stress [15,24] .

Saini and associates (2011) stated that more preponderant convexity of zygomatic arch in males may be associated with the outward push exerted by the hypertrophied belly of temporalis muscle which passes beneath the zygomatic arch [30]. It may also be due to the effect of gonadal hormones, sex-specific gene actions, or both [31].

Though the cranial patterns are population specific features, affected by environmental factors such as diet, climate and culture, yet, the bizygomatic breadth represents an important feature in evaluating the sexual dimorphism in several populations, and should always be considered in sex determination for human identification [3].

Upper Facial Index: Face Types

The upper facial index is percentage ratio of upper facial height (nasion-prosthion height) to facial width (bizygomatic breadth). It is one of the important parameter to differentiate between different human races. According to Banister's [6] classification and El-Najjar [18] classification, the facial shapes are divided into five types based on upper facial index as shown in Table-2 (i). By this classification, most of the skulls in the present study were Euryene (broad faces), with few skulls falling under Hypereuryene (very broad face) and Mesene (round face) category. Leptene to Hyperleptene (long to very long faces) were rare.

In the study by Prasanna et al. (2013) [12], according to Banister's classification of upper facial index; south Indian males had long faces (leptene) to round faces (mesene) and South Indian females had broad (euryene) to long face types; whereas north Indian males were found to have very long faces and females showed very long to round faces. Ghosh and Malik's (2007) [32] study which was done on West Bengal population (India) determined that Indians from this area had broad to very broad faces in both genders.

Higher upper facial index observed in North Indian and Thai skulls indicate that these populations have longer faces than the study population [15,26]. This difference may have been caused by environmental factors (geographical variations) or food habits, which may have led to an increased size of the maxillary alveolar arch.

Upper Facial Index: Sexual Dimorphism

Upper facial index has been recently proposed as a novel sexually dimorphic morphologic index. In the present study, mean upper facial index in male skulls was 48.36±2.52, while it was 46.60±2.72 in female skulls with statistically significant difference (Table.1). These results support prior findings in which this index was found to be significantly higher for the male crania than for the female crania (Table 5) [12]. Zaki et al. (2012)[24] and Vidya et al. (2012)[25] observed higher upper facial index in male skulls than female skulls; however, the difference was statistically not significant.

Contrary to above observations, Lefevrea et al. (2012)[9] found higher upper facial index in females than in males. They tested for sexual dimorphism of this index (facial width to height ratio-fWHR in particular) in four adult (three Caucasian and one African) independent samples of human facial photographs. In three of the four samples, no significant sex differences were observed. Moreover, in all cases, mean fWHR of women was higher than that of men and in one sample it was significantly higher in women. Hence his study suggested that there are no sex differences between males and females in fWHR as measured on the surface of the face in either Caucasian or African populations [9]. One of the possible reasons for fWHR not sexually dimorphic in the study by Lefevrea et al. (2012)[9] is that women, even when controlled for BMI, have greater facial adiposity, especially around the cheeks, than men.[33] This difference in facial adiposity may

Table 5: Comparison of means of Upper Facial Index of Males and Female skulls

Sr. No.	Name and year of the study	Study Sample (No. of skulls)	Male	Female	Study population	Mean Upper Facial Index Males	Mean Upper Facial Index Female	Significance (p Value)
1	Present Study (2017)	100	60	40	Indian	48.36	46.60	P<0.05 S
2	Prasanna et al. (2013)[12]	200 persons	100	100	Indian (100 south Indian+100 North Indian)	58.72	56.36	P<0.001 HS
3	Lefevrea et al. (2012)[9]	4 diff.samples			Photographs only	LOWER	HIGHER	NS
4	Zaki et al. (2012)[24]	Xrays of ancient 149 skulls of Greco-Roman period	90	59	Bahriyah oasis	35.303	35.263	P=0.940 NS
5	Vidya et al. (2012)[25]	80 skulls	41	39	South Indian	48.13	47.85	P=0.850 NS

potentially conceal a sex difference in bone structure: men may have higher bizygomatic width than women, but this difference may not be apparent in 2D or 3D face measures because sex differences in facial adiposity obscure or reverse differences in fWHR when measured from the skin surface. Another possible reason for fWHR to be insignificant for sexual dimorphism in the study by Lefevrea et al. may be the

fallacies in the technique of measurement from photographs and not actual persons or skeleton.

From above discussion, it is clear that the upper facial height, bizygomatic breadth and upper facial index are highly dimorphic and statistically highly significant parameters for gender differentiation. Also, values of all of these parameters are more in males than females and corroborate with previous studies which reported that most human craniofacial measurements, in particular the linear ones, show statistically significant sex differences and male skulls are 8.5% larger than female skulls]27,28].

The results of this study will be useful in anthropological research, facial reconstruction surgeries, for medico–legal purposes and for estimating the stature and sex of an individual in study population [10,12,25]. It should, however, be kept in mind that sex estimation from crania using metric method though suitable in all population groups, but the most dimorphic variables can vary relative to the regional population concerned, even within the same population of different time frame [15].

Conclusion

1. In the present study the mean upper facial height in male and female skulls was 61.71±3.65mm and 56.49±3.15mm respectively with statistically significant difference.
2. The mean bizygomatic breadth in male and female skulls was 127.63±4.79mm and 121.33±4.28mm respectively with statistically significant difference.
3. The mean upper facial index was 48.36±2.52 in male and 46.60±2.72 in female skulls with statistically significant difference placing the Indian study population in Euryne (broad faces) to Mesene (round face) group.
4. This study reaffirms that the upper facial height, bizygomatic breadth, and upper facial index are significant sexually dimorphic traits.
5. The knowledge of facial morphometry of adult Indian skulls provided by this study will be helpful in anthropology and forensic medicine for evaluation of race and sex as well as in facial reconstruction surgeries, in evaluation of facial trauma and identification of certain congenital malformations. It will also be useful in studying growth trends and in orthodontics.

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None

Conflicts of Interest: None

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