

A Morphometric Forensic Analysis using Cranio-Facial & Odontological Indices in Stature Estimation

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Abstract

Purpose: Forensic anthropology involves the examination of human remains for medicolegal purposes. Age, sex, and stature are critical aspects of identifying unknown individuals. Stature estimation can be achieved through various morphometric indices. The aim of the present study was to estimate and correlate the stature of an individual using odontometric and craniofacial indices.

Methods: The study included 100 subjects from the Haryana population. Odontometric and craniofacial measurements were taken, and different indices were calculated using standardized formulas. Data analysis was conducted using SPSS (Statistical Package for Social Science).

Results: A significant correlation was observed between odontometric and craniofacial indices and an individual's stature. The left central incisor index and right canine index showed better correlation with stature in both males and females. The highest variance was observed with the nasal index in both genders.

Conclusions: The findings indicate a positive correlation between odontometric and craniofacial indices and stature. These results can aid forensic investigations by improving methods of identification.

Key words: Forensic, Anthropology, Cranio-facial, Odontology, Indices, Stature, Statistics etc.

Introduction

Anthropology is the science of human beings, human conduct and societies in the past and present time. Forensic anthropology is a specialized branch of anthropology which involves the application of

knowledge and techniques of physical anthropology to solve the problems of medicolegal significance for the purpose of legal investigation. Identification of unknown is the prime question to be answered by a forensic anthropologist. It is a comprehensive science

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that implies the cognition of human osteology & biological anthropology to resolve the cases. It also provides a detailed apprehension of the morphology, reactive norms, growth and development of the human body that help in the individual identification of any person. Besides all above, it may have the broad application in the forensic identification of human, which applies to both the dead and the living individual¹. Anthropometry comprises of systematic measurements of the human body which includes skeleton remains of individual. Different parameters such as somatometry, cephalometry, osteometry, craniometry and odontometry are used in anthropometry^{12, 18}. Somatometry is a branch of anthropometry which deals with the quantitative measurements of different parts of body including mainly head and face².

Stature is considered as the one of the valuable parameters of forensic anthropology. It is used for identification of a person which helps in the investigation process¹⁴. It is the height of individual in upright position. It has a greater and positive correlation with all the body part of human. Anthropologist or forensic experts can measure various body dimensions and put these anthropometric measurements into a regression equation based on gender and race. This can be helpful in estimating the height of individual¹¹. Odontometry and cranio-facial anthropometry can be used for height estimation of an individual as growth of the measurements of face, head and teeth is little different from the measurements of the other parts of body^{5-6, 8, 18}. The present study was designed to correlate the stature of an unknown with cranio-facial indexes and odontological indices in Haryana population.

Methods

(A) Aim & Objectives: Maxillary anterior teeth and cranio-facial measurements are one of the important tools for determination of stature in forensic & legal medicine. The aim of the present study was to estimate the stature from maxillary odontometric and cephalometric measurements and correlate various tooth, cranial and facial indices with the height of individual. The objectives framed for the study was as follows:

- To measure height of individual
- To correlate stature with following
 - o Inter canine width of maxilla.
 - o Interincisor width of maxilla.
 - o Left central incisor index of maxilla.
 - o Right central incisor index of maxilla.
 - o Left lateral incisor index of maxilla.
 - o Right lateral incisor index of maxilla.
 - o Left canine index of maxilla.
 - o Right canine index of maxilla.
- To measure and correlate stature with following
 - o Maximum length of head and maximum breadth of head.
 - o Facial length and facial width.
 - o Nasal length and nasal breadth.
 - o Ear height and ear breadth.
- To establish the correlation between above mentioned anthropometric measurements.

(B) Study design and setting: Cross-sectional in design

(C) Characteristics of study participants:

The sample size of 100 participants (comprising 50 males and 50 females) was determined to ensure gender parity and to facilitate comparative analysis across sexes. The age range of 15–30 years was selected to capture a demographically relevant cohort for the study objectives, which focus on youth and young adults in Haryana. A purposive sampling technique was employed to specifically recruit individuals within this age group and geographic region, thereby aligning the sample with the study's contextual and research requirements. This approach allows for targeted data collection while maintaining internal validity within the defined population parameters. Measurements were taken with the help of vernier calliper, divider, measuring tape only after the signing the written consent by them. The study protocol was

approved by Institutional Human Ethical Committee (IHEC), Maharshi Dayanand University, Rohtak with the reference number IHEC no. 02/06.05.2017 Dated on 06-05-2017 at 2:00 PM.

(D) Inclusion and Exclusion criteria

Apparently healthy individuals with no physical deformity and only those people belonging to Haryana were included in the study. People from other regions, those with poorly endocrinal disorders, metabolic disorders & orthognathic surgery or trauma were excluded from the study.

(E) Methodology of odonotometry parameters (Figure 1)

1. **Measure Height of individual:** - Subject was allowed to stand up on a horizontal plane with his heels joined, stretching the body erect. The height of the individual was taken with the use of a non elastic measuring tape from vertex to feet.
 2. **Maxillary left/right central incisor index:** - Index was calculated as, Height of teeth (incisal edge to cervical line)/ Width of teeth (mesiodistal width)*100
 3. **Maxillary left/right lateral incisor index:** -Index was calculated as, Height of teeth (incisal edge to cervical line)/ Width of teeth (mesiodistal width)*100
 4. **Maxillary left/right canine index:** -Index was calculated as ,Height of teeth (incisal edge to cervical line)/ Width of teeth (mesiodistal width) *100
 5. **Inter canine width of maxilla:** -Measured from left canine to right canine.
 6. **Interincisor width of maxilla:** - Measured from left lateral incisor to right lateral incisor.
2. **Facial index:** It is the ratio of facial height to the facial width.
 - Facial Height: It is measured as the straight distance between nasion (root of nose) and ganthion in the mid saggital plane.
 - Facial Width: It is measured as the straight distance between two zygia (zygion to zygion).
 3. **Nasal index:** It is the ratio of nasal height to the nasal breadth.
 - Nasal Height: It is measured as the straight and vertical distance between nasion (root of nose) and nasal base.
 - Nasal Breadth: It is measured as the straight distance between two alaria (two lateral sides of nose).
 4. **Ear index:** It is the ratio of ear length to ear breadth.
 - Ear Height: It is measured as the straight and vertical distance between supra aurale and aurale base.
 - Ear Breadth: It is measured as the distance between the two most lateral points of the ear

(F) Methodology of cranio-facial anthropometry

The various anthropometric measurements used in the present study are described below^{11, 15} (Figure 2)

1. **Cranial Index:** It is the ratio of maximum length of head to the maximum breadth of head.

Results

The present study comprised of 50 males & 50 females belonging to different districts of Haryana. The data collected was analysed with statistical software program SPSS (Statistical Package for Social Science) version 22.

(A) Result and observations of odontometric parameters

The result of teeth measurement showed a significant correlation between the stature & left central incisor index (0.215). Therefore, we may conclude that there is a significant positive correlation between left central incisor index and height which means that higher the left central incisor index, taller will be individual.

The descriptive statistics for the eight parameters was recorded. It was observed that the mean stature for males was 172.9. Stature was observed to be higher in males as compared to females. Among the maxillary anterior teeth measurements, right lateral incisor index was observed to be the largest and inter incisor width as the smallest measurement. Inter incisor width was showing the minimum variance while right canine index was found to have the maximum variance among males (Table 1).

In females, a highly significant correlation was found between the stature & right canine of maxillary anterior teeth (0.30203). Therefore, we may conclude that there is a significant positive correlation between right canine of maxillary anterior teeth and height which means that higher the right canine index, taller will be individual. The descriptive statistics for the measurements of the eight parameters were recorded in the study subjects. It was observed that the mean stature for females was 160.75. Stature was observed to be higher in males as compared to females. Among the maxillary anterior teeth measurements, left lateral incisor was observed to be the largest (mean= 115.75) and inter canine width (mean= 3.846) as the smallest measurement. Inter canine width was observed to have the minimum variance while right central incisor was found to have the maximum variance among females (Table 2).

Pearson's correlation and regression analysis between the stature and left central incisor index is highly significant in males as compare to other maxillary anterior teeth indices. In female, the significance of Pearson's correlation and regression analysis between the stature and right canine index is high as compared to other maxillary anterior teeth.

(B) Result and observations of craniofacial parameters

The results of the present study showed a significant higher correlation within the dimensions of some craniofacial measurements. Ear index obtained was found to be highly correlated with stature in males while in females, facial index showed the least correlation with stature.

The descriptive statistics for the measurements of the six parameters were recorded in the male study subjects (Table 3). It was found that the mean stature in case of male population was 173.91. Stature was found to be higher in males as compared to female population. Among the craniofacial measurements for the male subjects, ear index (mean = 140.87) was found to be having the highest value and facial index (mean= 98.81) showed the lowest value. Mean for cranial index, circumference of head and nasal index for male subjects was 115.44, 56.9 and 120.35 respectively. Facial index was showing the least variance and nasal index was showing the highest variance in males. In case of males, a higher and positive correlation was found between all the craniofacial indices and stature except for cranial index. The correlations of various indices varied between 0.080156 for ear index and 0.058 for circumference of head in male study subjects (Table 4).

The descriptive statistics for the measurements of the six parameters were recorded in the female study subjects separately. It was found that the mean stature in case of females was 161.6 (Table 5). Among the craniofacial measurements of females, ear index was found to be having the highest mean value (mean=143.68) and facial index (mean=102.52) showed the lowest value. Mean for cranial index, circumference of head and nasal index for females subjects was 114.6, 53.94 and 131.96 respectively. Least variance was showed by facial index while nasal index showed the highest variance in female population. In case of females, a statistically positive correlation was obtained between all craniofacial indices and stature. Correlations varied between 0.3841 for facial index and 0.2239 for nasal index in case of female study subjects (Table 6).

Table 1: Showing Correlation & Descriptive statistics analysis for odontometric parameters recorded for males

Parameters	No	Range	Max.	Min.	Sum	Mean	SD	Variance	Correlation
Left central incisor index	50	55.15	137.5	82.35	5635.98	112.71	82.65	6832.37	0.215
Left lateral incisor index	50	33.33	133.33	100	5782.84	115.65	64.49	4159.13	-0.0924
Left canine index	50	90.48	157.14	66.66	5854.69	117.09	113.39	12858.6	0.0814
Right central incisor index	50	50	137.5	87.5	5750.53	115.01	76.88	5911.44	0.182
Right lateral incisor index	50	48.33	141.66	93.33	5840.94	116.81	82.97	6884.76	0.055
Right canine index	50	65.21	146.46	81.25	5726.03	114.52	113.50	12883.1	0.158
Inter canine width	50	1.7	5.3	3.6	230.8	4.61	5.16	26.69	0.132
Inter incisor width	50	1.3	4.4	3.1	196.8	3.93	5.47	29.94	0.146
Height	50	22.86	185.4	162.5	8628.6	172.57	38.06	1448.76	–
Age	50	15	30	15	1082	21.64	31.26	977.52	–

Table 2: Showing Correlation & Descriptive statistics for the odontometric parameters recorded for females

Parameters	No.	Range	Max.	Min.	Sum	Mean	Sd	Variance	Correlation
Left central incisor index	50	45.89	140	94.11	5698.8	113.97	72.29	5226.07	-0.0079
Left lateral incisor index	50	45.45	145.5	100	5787.9	115.75	75.20	5656.46	-0.1766
Left canine index	50	42.86	128.6	85.71	5492.6	109.85	67.22	4518.64	0.24338
Right central incisor index	50	38.62	127.5	88.88	5410.2	108.20	117.18	13732.07	0.07321
Right lateral incisor index	50	55.95	133.3	77.38	5600.1	112.00	86.03	7402.42	-0.2293
Right canine index	50	41.96	135.7	93.75	5475.8	109.51	61.13	3737.01	0.30203
Inter canine width	50	0.8	4.25	3.45	192.3	3.84	1.29	1.66	-0.0705
Inter incisor width	50	1.3	5.1	3.8	225.69	4.51	1.74	3.03	0.00973
Height	50	17.78	172.7	154.9	8037.8	160.75	27.00	729.32	–
Age	50	15	30	15	1106	22.12	27.33	747.28	–

Table 3: Descriptive statistics showing stature and craniofacial dimensions among male population

Parameters	N	Range	Max	Min	Sum	Mean	SD	Variance
Height	50	22	186	164	8695.9	173.91	39.468	1557.99
Cranial index	50	44.58	142.85	98.27	5772.4	115.44	73.922	5464.51
Circumference of head	50	6	59	53	2845	56.9	9.219	85
Facial index	50	21.41	109.31	87.9	4940.5	98.81	98.81	1486.81
Nasal index	50	87.31	180.64	93.33	6428.8	128.57	128.57	14485.56
Ear index	50	41.58	158.97	117.39	7043.8	140.87	140.87	4128.06

Table 4: Correlation obtained between stature and various craniofacial indices in males

Parameters	Correlation
Cranial index	-0.1324
Circumference of head	0.058
Facial index	0.0455
Nasal index	0.0134
Ear index	0.080

Table 5: Descriptive statistics obtained between stature and various craniofacial dimensions among female population

Parameters	N	Range	Max	Min	Sum	Mean	SD	Variance
Height	50	18	169	151	8080	161.6	28.46	810
Cranial index	50	51.12	145.45	94.33	5730.9	114.6	74.51	5552.9
Circumference of head	50	7.5	58.5	51	2697	53.94	73.37	178.82
Facial index	50	29.05	118.94	89.89	5126.02	102.52	60.77	3693.46
Nasal index	50	61.6	163.07	101.47	6598.16	131.96	145.2	21105.8
Ear index	50	33.38	161.64	128.26	7184.22	143.68	61.86	3827.76

Table 6: Correlation observed for stature and various craniofacial indices in females

Parameters	r
Cranial index	0.208186
Circumference of head	0.205736
Facial index	0.384133
Nasal index	0.223925
Ear index	0.053627



Figure 1: Showing the odontometric parameters used in the study

- (A) Height of tooth (B) Width of tooth
- (C) Intercanine width (D) Interincisor width

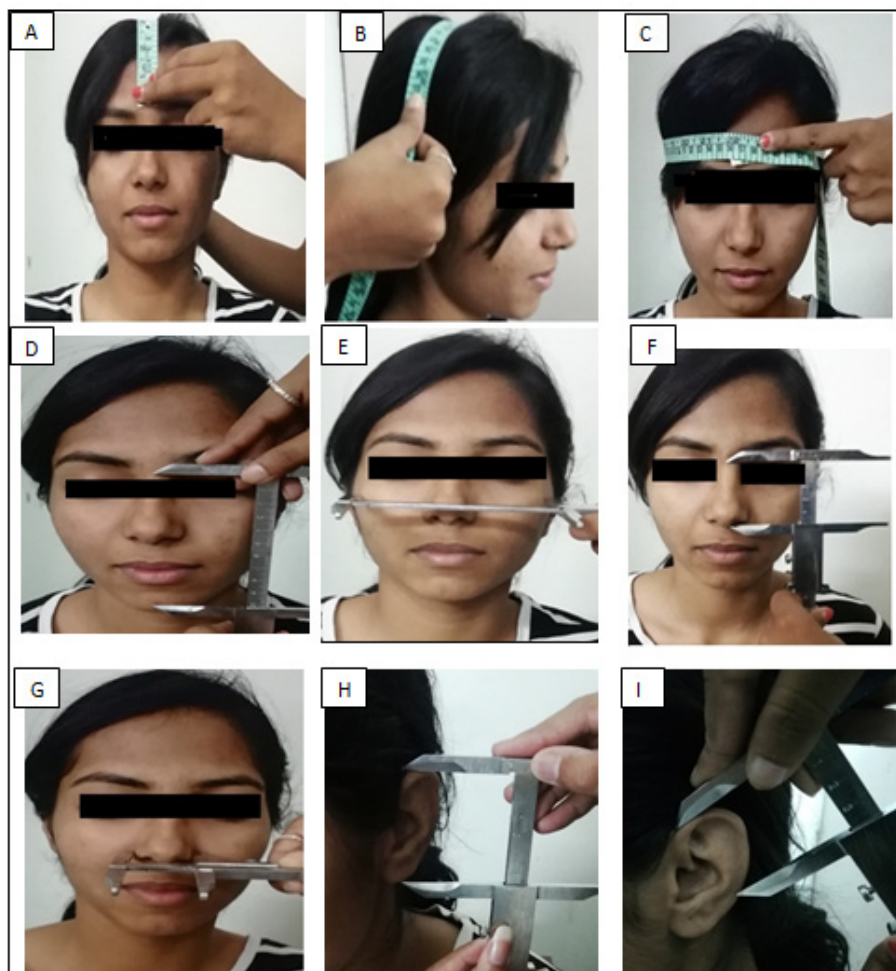


Figure 2: Showing the measurements used in the study A) Head Length B) Head Width C) Head Circumference D) Facial Height E) Facial Width F) Nasal Height G) Nasal Breadth H) Ear Height I) Ear Breadth

Discussion

In forensic science, the identification of a person from mutilated body or fragmentary remains has become an important aspect. In addition to age, sex, ancestry and stature are other biological parameters that characterize an individual^{19,20}. Human teeth and skull growth perform an indispensable function for clinical study material in both living and non-living population to make investigations like in anthropology, genetics odontogenic & forensic studies. Studies related to stature estimation from odontometric parameters & cephalometric parameters aimed to provide the valuable data pertaining to the stature of the individual²¹.

Present study found a very significant correlation of odontometric indices with stature of the individual

which is in accordance with the previous studies^{4, 6-7, 10, 16, 22}. In present study, left central incisor index showed significant correlation in males while in females, the right canine index showed high correlation with stature.

In the present study, the correlation was found to be maximum for ear index and minimum for cranial index in males. In females, correlation was found to be maximum for facial index and minimum for ear index. Krishanconducted a study on 996 adult male Gujjars from North India, establishing a strong and positive correlation between five cephalofacial measurements and stature¹¹. Sahni *et al.* (2010) studied the seven facial measurements to estimate stature in 300 healthy subjects from northwest India¹⁸. They estimated that the stature determined through regression analysis of seven facial measurements closely matched the

mean actual stature in both males and females, whereas the difference was found to be larger when using multiplication methods. Shrestha *et al.* (2015) assessed head length stature to predict the stature of an individual¹⁹. They established definite correlation between stature and head length. Furthermore another studies showed cephalic dimensions had highest and positive correlation with that of stature than facial dimensions^{1, 12, 15}.

Conclusions

The present study concludes that both odontometric and craniofacial measurements are reliable adjuncts for stature estimation and can play a significant role in forensic identification, especially in scenarios involving mass disasters or mutilated remains. These parameters provide valuable data when long bones are unavailable, aiding in the identification process.

However, the study is limited by its small, region-specific sample and restricted age range (15-30 years), which may affect the generalizability of the findings. The cross-sectional design and exclusion of individuals with craniofacial or dental anomalies further limit its applicability in real-world forensic cases.

Future studies should include larger, more diverse populations and wider age ranges to improve external validity. Incorporating advanced imaging techniques and exploring AI-driven predictive models could enhance accuracy and broaden the utility of these methods in forensic science.

Key Points

- The study's findings can enhance forensic identification methods by providing a reliable means of estimating stature from odontometric and craniofacial measurements.
- Aiding in crime investigations and disaster victim identification.
- Examination of human remains for medicolegal purposes.

Source of funding: Nil

Conflict of interest: Nil

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