Original Article

Odontometry and Skull Anthropometry: A Possible Tool for Stature Estimation using Minimum Armamentarium

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Abstract

Introduction: In the Asia Pacific region, because of variation in topography and climatic conditions, India is a disaster-prone country. The identification of an individual is one of the most important aspects of forensic medicine. There are different methods for identification of a person's age and gender. However, there are relatively fewer methods to estimate the stature of an individual. Stature correlation to skull and jaw dimensions is less frequently reported. The aim of the study is to investigate the relationship between height of the person and diameter of the head (DH) and circumference of the head with the combined mesiodistal (MD) width of maxillary anterior teeth using minimum and easily available armamentarium.

Materials and Methods: Fifty model casts of students were considered to measure the MD width of the anterior teeth along with the circumference of the head and DH (distance from glabella to inion) with the help of a nonstretchable measuring tape. Heights of the students were recorded in inches. All the findings were tabulated and statistically analyzed.

Observations and Results: When combined MD width of the maxillary anterior teeth was plotted against height, a statically significant correlation was seen. When head circumference was plotted against height, a higher correlation was seen. When two measurements were added and plotted against height, improved elevated correlation was seen. Similarly, when the MD width was added to circumference of the head and DH, a greater correlation was observed.

Conclusion: It can be safely concluded that with more data to prove the study, a formula can be drawn to estimate the height of the person using MD width of the anterior teeth, DH, and circumference of the head.

Key Words: *Forensic dentistry, head anthropometry, odontometry, minimum armamentarium, stature estimation*

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Introduction

The main aim of forensic sciences is the identification of individuals at the accident and disaster sites as the bodies are usually mutilated. Forensic odontology plays an important role in such identification. Great personalities such as Zia-ul-haq and Rajiv Gandhi were identified with the help of forensic odontology.[1] Previous dental records and old dentures were the most commonly used methods of identification back then. Today, an entire library can be created for rugae pattern to determine the age and gender of an individual; genetic information of an individual can be obtained from the pulp.[2]

As stated by Fédération Dentaire Internationale, "forensic odontology is the branch of dentistry which, in the interest of justice, deals with proper handling and examination of dental evidence and with the proper evaluation and presentation of dental findings."[3] Stature or body height is an important anthropometric parameter that can be used to determine the physical identity.[2,4] Proportional biological relationship of stature exists with every part of the human body including head, face, trunk, and extremities, which plays a vital role in forensic examination to calculate the stature from dismembered and mutilated body parts.[5]

The forensic pathologists/anthropologists can measure the dimensions of available body parts for examination and put these measurements into a mathematical formula as per gender and ancestry group. The formula produces a height range and helps in stature estimation.[6]

Various studies have been conducted in the past to compare and evaluate the anthropometric and odontometric tools for stature estimation.[7-19] Garn *et al*. studied the correlation between stature and mesiodistal (MD) and buccolingual dimensions of permanent maxillary lateral incisor.[8] A similar study in the African-American population showed correlation

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between stature and maxillary central incisor tooth width in males.[9] Introna *et al.* in 1993 discussed correlations between cranial diameter and height;[10] Kalia *et al.* in 2010 estimated the height of a person from teeth using lateral cephalogram for skull measurements.[11]

Usually, long bones are used for stature estimation; however, this becomes difficult when the bodies are fragmented or mutilated. Teeth are relatively resistant to decay and skull measurements have definite anatomical landmarks that are easy to locate; careful study of the teeth can thus enable reliable determination of stature of an individual when other predictors destroyed or fragmented.[12]

With this in view, the present study was undertaken to determine the possibility of estimating the height of an individual using the odontometric and anthropometric data of the head, using minimum armamentarium as may be available in the remote areas, which has not been done before.

Materials and Methods

The protocol of this study was approved by the Research, Ethical and Higher Degrees Committee of the Faculty of Dental Sciences, Dr. D. Y. Patil University School of Dentistry, Navi Mumbai, India. The study was observational, cross-sectional, and descriptive with some analytical components. The study was conducted from January 2015 to December 2015 at Dr. D. Y. Patil University School of Dentistry, Navi Mumbai, on 100 healthy individuals in the age range of 18–21 years. Informed consent of all the participants was obtained before conducting the study.

Inclusion and exclusion criteria

- All individuals selected were in the age group of 18–21 years; they had complete set of fully erupted, periodontally healthy, noncarious, nonworn intact and satisfactorily aligned anterior teeth.
- Patients with cleft palate or crown restorations, no history of orthodontic treatment, orthognathic surgery, trauma or surgery to the skull. Patients with evidence or clinical features suggestive of endocrinal disorders, metabolic disorders, developmental disorders, or history of prolonged illness were also excluded.

Methods of data collection

Impression casts

One hundred alginate (irreversible hydrocolloid material) impressions of the participants were made, and casts were poured with dental stone carefully, to record all the surface details. The greatest MD crown widths of the maxillary anterior permanent six teeth were measured between the anatomic contact points of each tooth on either side of the jaw, using manual divider with very fine tips, which was then coincided with units on a calibrated steel scale to obtain values of significance [Figures 1 and 2].

Measuring head diameter

Anteroposterior diameter of the head (DH) was measured using a nonstretchable measuring tape. Supraorbital ridges were palpated and the midpoint was marked. Similarly, the deepest point on the external occipital protuberance was marked and the distance between the two was measured [Figure 3].

Figure 1: Armamentarium used for measurement

Measuring the head circumference

Maximal fronto-occipital circumference was measured by placing a nonstretchable plastic tape (calibrated in millimeters) just on the occipital prominence and the supraorbital ridges while viewing the subject laterally also to ensure proper placement of the tape. In cases of some hairstyles in males, we drew the tape tightly and compressed the hair as much as possible. In cases of females, we asked the participants to lift their hair in the occipital area and the tape was placed against the skin and not over the lumps of hair. This method was in accordance with the one used by Everekliogl *et al.*[13] [Figure 4].

Height

Height was measured as the vertical distance from the vertex to the floor. Measurement was taken by making the participant stand erect on a horizontal plane barefooted. The participant was placed in straight vertical position with head oriented in neutral natural horizontal facial plane. All measurements were taken from 9 am to 12 pm to avoid any diurnal variation in stature[14] [Figure 5].

All the measurements were done by a single examiner to eliminate interobserver error. All the dimensions were measured three times for each tooth, and the average was recorded to minimize the intraobserver error.

Observation and Results

The data collected were subjected to statistical method for correlation and the linear regression formula was obtained for each parameter separately and in combination with other parameters. The Statistical software IBM SPSS statistics 20.0

(IBM Corporation, Armonk, NY, USA) was used for the analyses of the data and Microsoft word was used to generate tables.

Height against mesiodistal

Then, height was correlated with the combined MD width of the anterior teeth, using regression model; *P* value was found to be 0.068. It was found that MD dimension determines the height up to 11% (R^2 = 0.107) and the correlation between these two variables is 0.327. The formula for regression model coefficient is " Y = mx + c." Hence, height (Y) =0.694 (m) × ([x] combined MD width of anterior teeth]) +20.776 (c) [Table 1].

Height against diameter of the head

When height was correlated with the DH, using regression model, *P* = 0.880, thus rendering it insignificant. It was found that head diameter determines the height up to 0.1% (R^2 = 0.001) and the correlation between these two variables was 0.028. The formula for regression model coefficient is "Y = mx + c." Hence, height (Y) = −0.024 (m) (DH) (x) +161.11 (c); standard deviation, beta values and graphical representation [Figure 4] of the regression model have been mentioned [Table 2].

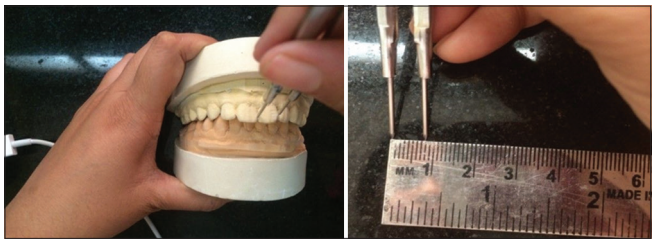

Figure 2: The technique used for measuring mesiodistal width of the anterior teeth

Figure 3: Measuring diameter of the head indirectly

Table 1: Regression model coefficient for combined mesiodistal width of anterior width when plotted against height

	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*
	B	SE			
C	120.866	20.776		5.817	0.000
m (coefficient of MD)	0.694	0.367	0.327	1.893	0.068

SE: Standard error, MD: Mesiodistal

Table 2: Regression model coefficient for diameter of the head when plotted against height

	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*
	B	SE			
C	161.118	6.594		24.432	0.000
m (coefficient of DH)	−0.024	0.157	−0.028	−0.152	0.880

SE: Standard error, DH: Diameter of the head

Table 3: Regression model coefficient for head circumference when plotted against height

	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*
	B	SE			
C	154.592	8.387		18.432	0.000
m (coefficient of HC)	0.112	0.167	0.121	0.667	0.510

SE: Standard error, HC: Head circumference

Table 4: Regression model coefficient when the sum of combined mesiodistal width and diameter of head was plotted against height

	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*
	B	SE			
C	151.925	14.814		10.255	0.000
m (coefficient of MD + DH)	0.084	0.151	0.101	0.556	0.582

SE: Standard error, MD: Mesiodistal, DH: Diameter of the head

Table 5: Regression model coefficient when sum of mesiodistal width of anterior teeth, head circumference, and diameter of the skull was plotted against height

	Unstandardized coefficients		Standardized coefficients (β)	*t*	*P*
	B	SE			
C	112.308	29.255		3.839	0.001
m (coefficient of MD + DH + HC)	0.324	0.198	0.286	1.636	0.112

SE: Standard error, MD: Mesiodistal, DH: Diameter of the head, HC: Head circumference

Table 6: Correlation between all the parameters individually and height

	MD	DH	HC	MD + DH	MD + DH + HC
HT					
Pearson's correlation	0.327	−0.028	0.121	0.101	0.286
P	0.068	0.880	0.510	0.582	0.112
N	32	32	32	32	32

**Correlation is significant at the 0.01 level (two-tailed).
MD: Mesiodistal, DH: Diameter of the head, HC: Head circumference, HT: Height

Height against head circumference

When height was plotted against the circumference of the head, *P* value was found to be 0.510 and Pearson's correlation of 0.121 was found Thus, head circumference (HC) determines the height up to 1.5% (R^2 = 0.015) and the correlation between these two variables is 0.121. The formula for regression model coefficient is "Y = mx + c." Hence, height (Y) = 0.112 (m) × HC (x) + 154.592(c); standard deviation, beta values [Table 3], and graphical representation of the regression model are mentioned.

Height against mesiodistal + diameter of the head

When the values obtained from MD width of the anterior teeth were added to the value obtained by measuring the DH and were correlated with the height, *P* = 0.582. Since *P* value for the MD + DH is greater than that of 0.05, it indicates that the MD + DH is not significant to determine the height.

It was found that the MD + DH determines the height up to 1.0% (R^2 = 0.01) and the correlation between these two variables is 0.101. The formula for regression model coefficient is "Y = mx + c." Hence, height (Y) = 0.324 (m) × (MD + DH [x]) + 112.308 (c) The regression equation is displayed on Figure 4 and Table 4.

Height against mesiodistal + diameter of the head + head circumference

When the sum of all the three parameters, i.e., combined MD width of anterior teeth, skull circumference, and DH, was regressed with height, the *P* value was found to be 0.112, indicating it to be insignificant. MD + DH + HC determines the height up to 1.0% (R^2 = 0.01) and the correlation between these two variables is 0.286. The formula for regression model coefficient is "Y = mx + c." Hence, height (Y) = 0.324 (m) × (MD + DH + HC [x]) + 112.308 (c). The regression equation is displayed on Figure 4 and Table 5.

Statistically, when *P* > 0.05, it was considered not to be significant. *P* value was lowest for HC value being 0.510 and highest for DH value being 0.880. *P* value for MD width of anterior teeth against height was found to be 0.068. When all the three parameters were combined and correlated with the height, the *P* value was found to be 0.112 [Table 6]. The Pearson's correlation coefficient, *r*, can take a range of values from +1 to −1. A value of 0 indicates that there is no association between the two variables. A value >0 indicates a positive association. Pearson's correlation coefficient was found to be 0.327 for MD (combined MD width of anterior teeth), −0.028 for DH (skull diameter), 0.121 for HC. Thus, Combined MD width of the anterior teeth shows the highest correlation. When the sum of all the three values, i.e., combined MD width of anterior teeth, circumference of the head, and head diameter, was plotted against height, the pooled data showed a correlation of 0.286 which is was greater than the correlation found between the head measurements but less than relation between MD width of the anterior teeth and height [Table 6].

Figure 4: Technique for measuring circumference of the head

Discussion

In forensic odontology, age and gender are the important parameters of a deceased individual. Sometimes, height also plays an important role in personal identification (the big four of forensic anthropology).[2] Stature estimation is most commonly done with the help of long bones.[15] However, in case of decomposed or mutilated bodies, it becomes difficult to do so. Some structures in the orofacial region are resistant to decomposition and hence can be used for stature estimation; teeth are a nondestructive, it is a simple process and can be applied to both living and deceased persons; other methods are relatively time-consuming, expensive, less reliable, and destructive, which may not be acceptable for

Figure 5: Technique to measure height

ethical, religious, cultural or scientific reasons;[16] however, these odontometric characters are specific to population, and hence, a distinct formula must be developed for the specific population. There are many studies available in the literature concerning the estimation of stature from anthropometry of cephalofacial region.[8-11] Studies for stature estimation have been done in the past. Agnihotri and Soodeen-Lalloo[17] studied 14 measurements (maximum head length, maximum head breadth, horizontal HC, head vault, minimum frontal diameter, bizygomatic breadth, bigonial diameter, nasal height, nasal breadth, nasal depth, morphological facial length, physiognomic facial length, physiognomic ear length, and physiognomic ear breadth) of cephalofacial region to observe the relationship with height in Indo-Mauritian population and successfully devised the regression formulae for the estimation of stature. Since the correlation coefficients of these measurements were <0.5, they were not considered as reliable predictors.

Similarly, Pelin *et al*.[18] observed that these percutaneous dimensions are not good predictors for estimating stature in a Turkish population. Krishan *et al*.[6] conducted a study in North Indian population to estimate the stature from cephalofacial anthropometry and indicated that all the cephalofacial measurements are strongly and positively correlated ($P < 0.001$) with stature. Akhter *et al*.[19] studied a sample size of 100 Bangladeshi Garo adult females and found a significant positive correlation of HC with the stature ($P = 0.005$).

Wankhede *et al*.[20] studied percutaneous maxillofacial anthropometry and found that it can be used but not as a primary method for stature estimation. Filipson and Goldhon demonstrated no correlation between tooth width and stature in Sweden population. This could be due to smaller sample size or difference in ethnicity.[21] A study done in Caucasians found no association between tooth width and stature.[22] Nevertheless, Garn *et al*. found a significant correlation between stature and MD and buccolingual dimensions of permanent maxillary lateral incisor, while no such correlation was found with maxillary central incisor.[8] Contradicting to this, another research in African-Americans found correlation of stature with maxillary central incisor tooth width in males, while lateral incisor did not show any such correlation.[9]

The current study was aimed at finding if odontometry can be used as a method of stature estimation, and on data analysis, it was found that *P* value of the considered parameters, i.e., the MD width of anterior teeth, head diameter, HC (measured using nonstretchable measuring tape), was not significant. Interestingly, the combined MD width of maxillary anterior teeth (canine to canine) found more correlation as compared to other parameters.

The present study was designed so as to determine the height using minimum armamentarium as may be available at disaster sites or in remote areas. The results obtained were not very significant; this could be due to use of simple measuring tape and not the scans and radiographs which would give the exact dimensions of the skull as also a smaller sample size. Furthermore, other studies have often used skull measurements, but, in the current study, it has considered direct head measurements. There may be a hope of better correlation if larger sample size and better method of data collection are used. In addition, if the measurement the hair was parted, the tape was held as close to the head as possible. If measurements are done by wetting the hair, it would probably minimize the density and thereby minimizing the errors due to same.

Further, other studies use radiographical landmarks, i.e., glabella to inion to measure the diameter of the skull. Due to the fact that, in the current study, we wanted to avoid radiographical exposure, we considered anatomical landmarks corresponding to the same.

One might expect taller people to possess longer teeth since they contribute to the height of the face,[23] there have been studies done to show relation between stature and posterior tooth length.[24] As also, studies showing undersized anterior teeth give unnatural appearance to the denture,[25] taller people tend to have a larger jaw and hence may have wider teeth,[26] all of this suggesting that there may be a definite proportionality between the odontometric parameters and height.

There have been cross-sectional studies to indicate decrease in the height of adult individuals demonstrating significant decline in stature with age, while no changes were seen in the subischial leg length or arm length across the age range of the study population;[27] this is of importance as the length of long bones is most frequently used for stature estimation. Hence, chances of insignificance might exist. Interestingly, a decrease in tooth height and width may be observed in older individuals as one of the age changes owing to occlusal and proximal attrition.[28]

A study was conducted on extracted maxillary central and lateral incisor of srilankan sialenese population by Jayawardena *et al*, to determine if there was an association between tooth length, height and age of an individual; taking into account total tooth length, crown length, and root length. It showed positive correlation between age and tooth length; however, there was no association between stature and tooth length indicating that genetic linkage between tooth size and stature was weak.[29,30]

MD width of the primary teeth is lesser as compared to MD width of permanent teeth, indicating that the height of an individual increases with age and so does the jaw size and the MD width. However, if there is a definite proportionality and if there can be a regression formula derived to predict height, specific to the population is yet to be explored. If there exists a definite proportionality, it can be harnessed to effectively predict the stature of an individual as he/she transits from child to adult. Considering that the complete MD width of the anterior teeth is achieved by the age of 13 years (±2) and complete growth of jaw occurs with the eruption of the second molar, but complete growth in terms of height takes place by 18–21 years of age.[25]

Conclusion

From the present study, it can be concluded that regression equations from the odontometric parameters cannot be used as a reliable approach for stature estimation; however, if careful longitudinal studies can be done on a larger sample size with the appropriate apparatus, optimal results may be obtained, specific to the population studied.

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Conflicts of interest

There are no conflicts of interest.

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