CORRELATION BETWEEN CROWN LENGTH OF PERMANENT MAXILLARY ANTERIOR TEETH, FACIAL HEIGHT AND LENGTH OF HAND DIGITS WITH THE STATURE OF AN INDIVIDUAL.

Forensic Medicine

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ABSTRACT

BACKGROUND: Personal identification is defined as establishing the identity of an individual. One of the objectives of the medicolegal investigation is to estimate stature or height from various skeletal remains and body parts brought for examination. Teeth can be considered as an exceptional resource material for forensic investigations because of its high resistance capacity to withstand high temperatures in disasters during natural or manmade calamities. Teeth play a vital role in individual identification for medicolegal circumstances and identification of unknown skeletal remains during mass casualties. We did a pioneer study to correlate anatomical crown length of maxillary anterior teeth, facial height and right-hand digits length with the stature of an individual for personal identification in Southern Kerala population by formulating an equation.

METHODS: A total of 250 volunteers participated in this study. The stature and anatomical crown length of maxillary anterior teeth, facial height, length of right-hand digits were measured. Statistical analysis was performed using computer software, Statistical Package for Social Sciences (SPSS) version 16.0 for Windows Operating System. Correlation between anatomical crown length of maxillary anterior teeth, facial height, length of right-hand digits with the stature of an individual was analyzed by Pearson correlation test. Regression analysis was used to get equations for estimation of stature from these parameters. **CONCLUSION:** The present study is possibly the first in Southern Kerala population that has attempted to estimate stature from anatomical crown length of permanent maxillary anterior teeth, facial height, and right-hand digits length by formulating a regression equation. We found some positive correlation between facial height and right-hand digits length with the stature of the individual. But there was no significant correlation between anatomical crown length of permanent maxillary anterior teeth with the stature of an individual. Although no definitive correlations could be established between anatomical crown length of permanent maxillary anterior teeth and stature or body height, the use of the established parameters will be helpful in the fields of forensic odontology and anthropology.

KEYWORDS

Stature Estimation; Anatomical Crown Length; Length Of Hand Digits; Correlation; Forensic Identification; Regression Equation.

INTRODUCTION:

Forensic odontology is defined by the Federation Dentaire Internationale as 'that branch of dentistry which, in the interest of justice, deals with the proper handling and examination of dental evidence, and with the proper evaluation and presentation of dental findings.(1) Personal identification is defined as establishing the identity of an individual. It may be complete (absolute) or incomplete (partial). Complete identification means absolute fixation of individuality of a person. Partial identification implies ascertainment of only some facts about the identity of the person while others still remain unknown.(2) The need for personal identification arises in natural mass disaster like earthquakes, tsunamis, landslides, floods etc., and in manmade disasters such as terrorist attacks, bomb blasts, accidents, mass murders, and in cases where the body is highly decomposed or dismembered to deliberately conceal the identity of an individual.(3) Stature is the height of a person in the upright posture. In identification of unknown human remains, stature estimation is a preliminary investigation.(4) Personal identification can be done by various methods and techniques, one of which is by estimating the stature.(5)

Teeth can be considered as an exceptional resource material for forensic investigations because of its high resistance capacity to withstand high temperatures in disasters during natural or manmade calamities. Hence, teeth play a vital role in individual identification for medicolegal circumstances and identification of unknown skeletal remains during mass casualties.(6)

The 'big fours' of personal identification are determination of age, sex, stature and ethnicity. These form the features of 'tentative identification'.(3) Personal identification can be done by various methods and techniques, one of which is by estimating the stature. Various studies have been done for estimating the stature of an individual by correlating the foot length, palm length and even ring and index finger with the height of a person.(5) There was no data available on correlating the height with crown length of permanent maxillary anterior teeth, facial height, right hand digits length. Therefore, this study aimed to cover this lacuna. The current study aimed to estimate the stature from anatomical crown length of permanent maxillary

anterior teeth, facial height, right hand digits length.(7)

MATERIALS AND METHODS:

A cross sectional study was conducted in the Department of Oral Pathology and Microbiology, Government Dental College, Thiruvananthapuram after obtaining ethical clearance from the institutional ethics committee. The period of study was from March 2018 to September 2019. The total cross-sectional sample consisted of 250 volunteers (Male= 88; Female= 162) between 18-60 years of age. The subjects were explained about the purpose of study and consent was obtained from each volunteer willing to participate in the study. A general population of subjects were chosen for the purpose of the research. Data on sex, age, anatomic crown length of permanent maxillary anterior teeth, facial height, right hand digits length and height of an individuals were taken and the anthropometric measurements were taken. The subjects were selected based on the following inclusion and exclusion criteria:

Inclusion criteria

1. Sound permanent maxillary anterior teeth.

Exclusion criteria

1. Evidence of dental irregularities.
2. Apparent loss of tooth structure due to fracture, caries or restorations.
3. Attritioned maxillary anterior teeth.
4. Individuals presenting any characteristics which could alter the contour of face and dentition.
5. Any systemic diseases and syndromic patients with malformed limbs.
6. Subjects who did not give consent.

Measurement of anatomical crown length

For teeth measurement anatomical crown length of permanent maxillary central, lateral and canine teeth on both the right and left quadrants were measured. The length of the anatomical crown was measured as the distance from CEJ to the midpoint of incisal edge by using William's graduated probe on the incisal edge (for central and lateral incisors) / tip of the cusp (for canines) to the highest point along the long axis of the crown on the labial aspect. Measurements were

recorded and later transferred to a standardized long metallic ruler to calculate the distance.

Measurement of facial height

On the face reference points were established by using erasable marker, and the measurements were obtained by using spreading caliper.

Reference points:

Two reference points were

1. From Glabella to Menton.
2. From Vertex to Menton.

Measurement of Right-Hand Digits length (DL) with Digital Vernier Caliper:

For the measurement of finger length, with the help of a Digital Vernier caliper, the right-hand digits length were measured from the linear distance (cm) between the proximal digital crease and the distal end of the first, second, third, fourth and fifth finger.

Measurement of Stature using Stadiometer:

Stature of subjects were measured as vertical distance from the vertex to the foot. Measurements were taken by making the subject to stand erect on a horizontal resting plane, on the stadiometer bare footed. Palms of hand turned inward and fingers horizontally pointing downwards and head oriented in eye-ear-eye plane (Frankfort plane). The movable rod of the stadiometer was brought in contact with vertex in mid sagittal plane. The measurements were taken in centimeters.

Statistical data analysis

Means of the parameters of the anatomical crown length of permanent maxillary anterior teeth, facial height, right hand digits length and stature for both male and female volunteers were calculated. Correlation test between the stature and the measured parameters was carried out by Pearson correlation test. Regression analysis was carried out to obtain equations for estimation of stature from the various parameters. The regression equations were used to get estimated stature in the same sample of volunteers from which regression equations were obtained.

RESULTS:

Mean value stature of the Southern Kerala females is 157.74 cm and for males 170.55 cm. Mean value and standard deviations for maxillary right central incisor (male 1.1 ± 0.16 ; female 1.0 ± 0.13); maxillary right lateral incisor (male 0.9 ± 0.12 , female 0.8 ± 0.10); maxillary right canine (male 1.0 ± 0.16 , female 0.9 ± 0.12); maxillary left central incisor (male 1.0 ± 0.15 , female 1.0 ± 0.13); maxillary left lateral incisor (male 0.9 ± 0.12 , female 0.8 ± 0.11); maxillary left canine (male 1.0 ± 0.16 , female 0.9 ± 0.12).

Mean value for facial height from Glabella-Menton for females is 11.40 ± 0.59 , Vertex-Menton is 21.48 ± 0.76 and for males from Glabella-Menton is 12.15 ± 0.73 , Vertex-Menton 21.82 ± 0.85 . Mean value for Right hand digits length for males- thumb 7.25 ± 0.59 , index finger 7.9 ± 0.52 cm, middle finger 8.67 ± 0.53 ,ring finger 8.2 ± 0.51 and little finger 6.77 ± 0.47 and for females thumb finger 6.69 ± 0.47 , index finger 7.45 ± 0.45 ,middle finger 8.17 ± 0.45 ,ring finger 7.73 ± 0.43 and little finger 0.42 .

Table 1: Descriptive statistics regarding anatomical crown length of permanent maxillary anterior teeth, facial height, right hand digits length and stature for male and female:

Variables		Mean (cm)	SD	Error	Minimum (cm)	Maximum (cm)
Maxillary right central incisor (cm)	Total (n=250)	1.12	0.15	0.01	0.70	1.40
	Male (n=88)	1.18	0.16	0.02	0.80	1.40
	Female (n=162)	1.09	0.13	0.01	0.70	1.40
Maxillary right lateral incisor (cm)	Total (n=250)	0.85	0.12	0.01	0.60	1.20
	Male (n=88)	0.90	0.12	0.01	0.70	1.20
	Female (n=162)	0.82	0.10	0.01	0.60	1.10
Maxillary right canine (cm)	Total (n=250)	0.98	0.15	0.01	0.70	1.40
	Male (n=88)	1.05	0.16	0.02	0.80	1.40
	Female (n=162)	0.94	0.12	0.01	0.70	1.30
Maxillary left central incisor (cm)	Total (n=250)	1.12	0.15	0.01	0.70	1.40
	Male (n=88)	1.18	0.15	0.02	0.80	1.40
	Female (n=162)	1.08	0.13	0.01	0.70	1.40
Maxillary left lateral incisor (cm)	Total (n=250)	0.85	0.11	0.01	0.60	1.20
	Male (n=88)	0.90	0.12	0.01	0.70	1.20
	Female (n=162)	0.82	0.11	0.01	0.60	1.10
Maxillary left canine (cm)	Total (n=250)	0.98	0.15	0.01	0.70	1.40
	Male (n=88)	1.05	0.16	0.02	0.80	1.40
	Female (n=162)	0.94	0.12	0.01	0.70	1.30
Glabella to Menton (G-M) cm	Total (n=250)	11.66	0.74	0.05	10.00	14.00
	Male (n=88)	12.15	0.73	0.08	11.00	14.00
	Female (n=162)	11.40	0.59	0.05	10.00	13.60
Vertex to Menton (V-M) cm	Total (n=250)	21.95	1.02	0.06	19.10	24.80
	Male (n=88)	22.82	0.85	0.09	21.00	24.80
	Female (n=162)	21.48	0.76	0.06	19.10	24.00
Thumb (1st digit) length (cm)	Total (n=250)	6.88	0.58	0.04	5.50	8.40
	Male (n=88)	7.25	0.59	0.06	5.90	8.40
	Female (n=162)	6.69	0.47	0.04	5.50	8.20
Index finger (2nd digit) length (cm)	Total (n=250)	7.61	0.52	0.03	6.20	8.90
	Male (n=88)	7.91	0.52	0.06	6.30	8.90
	Female (n=162)	7.45	0.45	0.04	6.20	8.40
Middle finger (3rd digit) length (cm)	Total (n=250)	8.34	0.53	0.03	7.00	10.00
	Male (n=88)	8.67	0.53	0.06	7.10	10.00
	Female (n=162)	8.17	0.45	0.04	7.00	9.60
Ring finger (4th digit) length (cm)	Total (n=250)	7.91	0.52	0.03	6.60	9.30
	Male (n=88)	8.24	0.51	0.05	6.90	9.30
	Female (n=162)	7.73	0.43	0.03	6.60	9.00
Little finger (5th digit) length (cm)	Total (n=250)	6.51	0.48	0.03	5.10	7.90
	Male (n=88)	6.77	0.47	0.05	5.10	7.90
	Female (n=162)	6.37	0.42	0.03	5.40	7.60
STATURE (cm)	Total (n=250)	162.25	8.80	0.56	140.50	185.00
	Male (n=82)	170.55	6.65	0.71	151.50	185.00
	Female (n=168)	157.74	6.14	0.48	140.50	175.50

Table 2: Correlation between anatomical crown length of permanent maxillary anterior teeth, facial height, right hand digits length (DL) with the stature (Y) of male and female.

Variables		Constant	B	SE	Pearson correlation coefficient, r	r2	t	Significance, p
Maxillary right central incisor	Male	170.24	0.26	6.69	0.006	0.000	0.058	0.954
	Female	156.81	0.86	-6.15	0.018	0.000	0.230	0.818
Maxillary right lateral incisor	Male	165.00	6.19	6.65	0.111	0.012	1.036	0.303
	Female	156.59	1.40	-6.15	0.024	0.001	0.303	0.763
Maxillary right canine	Male	162.91	7.26	6.59	0.170	0.029	1.602	0.113
	Female	155.02	2.91	-6.14	0.057	0.003	0.726	0.469
Maxillary left central incisor	Male	170.75	-0.17	6.69	0.004	0.000	-0.036	0.971
	Female	157.41	0.30	-6.15	0.006	0.000	0.080	0.936
Maxillary left lateral incisor	Male	164.66	6.58	6.65	0.115	0.013	1.074	0.286
	Female	158.67	-1.14	-6.15	0.02	0.000	-0.248	0.805
Maxillary left canine	Male	162.89	7.28	6.59	0.171	0.029	1.608	0.112
	Female	155.02	2.91	-6.14	0.057	0.003	0.726	0.469
Glabella to Menton (G-M)	Male	135.69	2.87	6.35	0.316	0.100	3.086	0.003
	Female	117.02	3.57	-5.77	0.346	0.120	4.666	0.000
Vertex to Menton (V-M)	Male	115.08	2.43	6.36	0.312	0.097	3.040	0.003
	Female	83.72	3.45	-5.56	0.428	0.184	5.997	0.000
Thumb (1st digit) length	Male	142.34	3.89	6.28	0.346	0.120	3.420	0.001
	Female	126.68	4.65	-5.76	0.353	0.125	4.776	0.000
Index finger (2nd digit) length	Male	118.17	6.62	5.74	0.514	0.264	5.557	0.000
	Female	113.01	6.01	-5.52	0.441	0.194	6.208	0.000
Middle finger (3rd digit) length	Male	102.05	7.90	5.22	0.625	0.391	7.425	0.000
	Female	98.74	7.22	-5.23	0.527	0.278	7.850	0.000
Ring finger (4th digit) length	Male	107.43	7.66	5.43	0.584	0.341	6.672	0.000
	Female	98.44	7.68	-5.17	0.542	0.294	8.162	0.000
Little finger (5th digit) length	Male	118.77	7.65	5.61	0.544	0.296	6.010	0.000
	Female	121.27	5.72	-5.67	0.388	0.150	5.320	0.000

P value < 0.001 is Significant **

Regression equations for estimation of Stature (Y):

A regression equation was formulated using the values obtained by linear regression analysis and the stature was estimated using that standard equation which is:

$Y = a + b x$; a = Constant, b = Regression coefficient, " x " = the measurement of a bone or body part.

Regression equations for estimation of Stature (Y) using facial height

Males:

Stature (Y) = 135.69 + 2.87 x G-M

Stature (Y) = 115.08 + 2.43 x V-M

Females:

Stature (Y) = 117.02 + 3.57 x G-M

Stature (Y) = 83.72 + 3.45 x V-M

Regression equations for estimation of Stature (Y) using right hand digits length

Males:

Stature (Y) = 142.34 + 3.89 x Thumb length

Stature (Y) = 118.17 + 6.62 x Index finger length

Stature (Y) = 102.05 + 7.90 x Middle finger length.

Stature (Y) = 107.43 + 7.66 x Ring finger length.

Stature (Y) = 118.77 + 7.62 x Little finger length.

Females:

Stature (Y) = 126.68 + 4.65 x Thumb length.

Stature (Y) = 113.01 + 6.01 x Index finger length.

Stature (Y) = 98.74 + 7.22 x Middle finger length.

Stature (Y) = 98.44 + 7.68 x Ring finger length.

Stature (Y) = 121.27 + 5.72 x Little finger length.

DISCUSSION:

In the present study evaluation of anatomical crown length of permanent maxillary anterior teeth showed a low correlation with stature (0.006 to 0.17). A study conducted by Jaywardena CK et al. in Sri Lankan Sinhalese population found that correlation between maxillary incisors and stature were low ($r = 0.07$) and was not significant (8). In another study done by Raghavendra N et al. in Karnataka population (2014) found there was no significant correlation between anatomical crown length of maxillary anterior

teeth with the stature ($r = -0.014$, $p = 0.893$). Prabhu S *et al.* have done a study in 2013 to ascertain the usefulness of tooth crown measurements in stature prediction. They used buccolingual and mesiodistal dimensions of all teeth (except third molars) and stature measurements were obtained from 95 living adults (47 females, 48 males). Ridge regression was performed for the dentition, which revealed a moderate but statistically significant correlation to stature ($R = 0.68$; $P < 0.0001$) (9). These findings are higher when compared to our study and this difference may be because they had taken buccolingual and mesiodistal diameter. This discrepancy may also be due to difference in teeth dimensions in the various ethnic groups considered in the study since it is a study conducted in Indian population. Henderson et al. reported a positive correlation between stature and mesiodistal and buccolingual tooth width of some teeth of African Americans. In the same study, permanent maxillary central incisor showed a correlation ($r = 0.32$) between stature and tooth width in males, while the lateral incisor of males and all the incisors of females failed to show such a correlation (8). It seems that the association between stature and tooth dimension is inconsistent depending on the tooth, sex and race. Therefore, from the findings of previous studies and ours, it is reasonable to state that inferring stature from the length of tooth is unwarranted. This also reflects that the genetic linkage between tooth length and stature is not strong.

In this study, the correlation coefficient values of anatomical crown length maxillary teeth ($r = 0.006$ to 0.17) were far below those of long bones ($r = 0.72$). This suggests that tooth crown length is less accurate in comparison to long bones for the estimation of stature. The standard errors of estimate (SEE) in regression analysis were higher ($SEE = 6.69$) than that of long bones ($SEE = 0.42$) (10). The tendency of tooth crown dimensions to have a low correlation to stature particularly when compared to long bones may be attributed to their differences in the time of growth completion. While tooth crown completion of all permanent teeth (except third molars) occurs by the age of ten years (range, 8 to 12 years), the closure of the epiphyseal lines of long bones (which ultimately affects stature) may take place from 17 to 19 years. Hence, unlike teeth, long bone length may be influenced by several environmental factors such as diet and exercise until much later ages and for an extended period. During the same period (approximately 12 to 19 years of age), however, tooth crown dimensions are not affected since no regeneration of enamel occurs upon crown completion, there is no possibility of addition to the tooth crown. Even if teeth did react to environmental stimuli, it would be in the form of excessive dentin formation within the tooth and toward the pulp. Overall, the low tooth-

stature correlation and relatively high Standard error of estimate (SEE) in the present study suggest that the dentition may only be used as a supplementary method to other more accurate variables of the skeletal system.(9)

There is a need to investigate whether any possible significant correlation exists between stature and facial dimensions. Considering this fact, an attempt had been made in the present study to estimate stature from facial parameters (Glabella to Menton and Vertex to Menton) by using regression equations.

In the present study in Southern Kerala population, the Pearson's correlation coefficient value between stature and facial height (from Glabella to Menton and Vertex to Menton) for both male and female was found to be positive. For males from Glabella to Menton the correlation coefficient $r=0.31$ with SEE 6.35; for females $r=0.34$ with SEE -5.77. For males from Vertex to Menton $r=0.31$ with SEE 6.36; for females $r=0.42$ with SEE -5.56. This value is nearly same to the value observed by Kharyal et.al in 2008 correlated total facial height and stature ($r=0.39$, SEE ± 6.65 for males and $r=0.35$, SEE ± 4.96 females) and inferior to the value obtained by Wankhede KP et.al in central Indian population ($r=0.19$, SEE ± 6.68 for males and $r=0.14$, SEE ± 5.84 for females).(11)

Agnihotri et al. studied 150 Indo-Mauritian students for stature estimation by using facial measurements and showed better correlation coefficient for males and females $r=0.328$ and this value was comparable with our study.(12)

K Krishan et al. conducted a study on 996 adults male Gujjars of Northern India from age group 8 to 30 years. Five cephalo-facial measurements were taken and the results indicated that cephalo-facial measurements were strongly and positively correlated ($p<0.001$) with stature. The measurements of the cephalic region had stronger correlation with stature than those of facial region. In another study conducted by K Krishan et al. on 252 Koli male adolescents from Northern India. Stature and sixteen cephalo-facial measurements were taken for study. As per their findings all the cephalo-facial measurements were significantly correlated with stature ($p<0.001$, $p<0.01$) but cephalic measurements had stronger correlation with stature than the facial measurements. This may be due to the fact that the growth of skull (cephalo-facial) is mainly genetically determined through local epigenetic factors such as growth of brain. As the stature of an individual is genetically determined, therefore, there must be some correlation between the stature and cephalo-facial measurements.(12)

This study was designed also to see if there was correlation between right hand digits length with stature. This was to investigate if these parameters could be used to predict stature as different body parts have been used for the prediction of height for the possible identification of individuals in forensic investigation. In our study we found all right-hand digits showed good correlation with stature in both males and females. For thumb, correlation coefficient for male $r=0.34$, SEE 6.28 for females $r=0.35$, SEE -5.76; index finger for males $r=0.51$, SEE 5.74 and for females $r=0.44$, SEE -5.52; Middle finger correlation ($r=0.62$, SEE 5.22) in males and ($r=0.52$, SEE -5.23) in females; ring finger for males $r=0.58$, SEE 5.43 and for females $r=0.54$, SEE -5.17; little finger for males $r=0.54$, SEE 5.61 and for females $r=0.38$, SEE -5.67. In our study the correlation value for middle finger is higher. This is in accordance to findings of a study conducted by Rahule *et al.* in Indian population where good correlation existed between right middle finger length and stature in males and females and higher correlation coefficient in females than males.(13) In our study the correlation coefficient was slightly higher (0.62) in males than females (0.52) suggestive of better correlation in males than females.

Study conducted by Suseelamma D et al. was the correlation between stature and length of fingers. The study was carried out in 200 subjects of age group 18-60 years. Pearson correlation between finger length and stature was higher among males as compared to females.(14) In our present study also we found correlation between right hand digits length and stature was higher among males as compared to females, for example in our study the obtained correlation between middle finger length and stature for males $r=0.62$ whereas for females $r=0.52$.

In this study we derived separate regression equations to estimate stature from facial height (Glabella to Menton, Vertex to Menton) and

right-hand digits length for Southern Kerala population. The obtained regression equations for male and female can be used for the estimation of stature of males and females of this population even if only an amputated hand is found and other body parts are unavailable. With this current study if the fingers or the hand of an individual is available then a probable estimate of the height of the individual can be done. It cannot give a conclusive prediction of the identity of the individual but can give a probable prediction.

CONCLUSION

Estimation of stature forms an important parameter to reach the partial identification of an unidentified body and dismembered remains. The present study is possibly the first in Southern Kerala population that has attempted to correlate the anatomical crown length of maxillary anterior teeth, facial height and length of right-hand digits with the stature of an individual, and explore the possibility to estimate stature from those dimensions by formulating a regression equation. Our results demonstrated that facial height and right-hand digits length have a statistically significant association with the stature of an individual in Southern Kerala Population. So, we formulated a regression equation to compute stature in Southern Kerala population from facial height and right-hand digits length. Our findings suggest that there was no positive significant correlation between stature and anatomical crown length of maxillary anterior teeth. Using anatomical crown length of maxillary anterior teeth as a tool may not give accurate estimation of stature in forensic situations. It is also noted that in this study, the data have been obtained from unworn and unrestored teeth which may not be encountered very often in real forensic situations.

This study has succeeded in establishing stature estimation from right hand digits length for this population which will not only serve as a useful tool in forensic investigation and clinical practice, but also relevance in ergo-design applications of hand tools and devices.

This study also signifies the importance of ante-mortem data of an individual to be collected and recorded on a nationwide basis and a proper data storing system should be formulated.

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There are no conflicts of interest.

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