Correlation and Estimation of Stature from Carrea's Index: A Study Among Two Populations in India

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Introduction

All human beings occupying this globe belong to the same species i.e., homosapiens. No two persons are ever alike in all their measurable characters, and the latter tends to undergo changes in varying degrees from birth to death, in health and diseases, and since persons living under different conditions, and members of different ethnic groups frequently present interesting differences in bodily form and proportions¹. In a forensic context, among the information potentially collected from human remains, estimated stature can be an important feature to be added to the criteria, helping to narrow the search for missing person's data². Stature is the height of a person in the upright posture and has a definite and proportional biological relationship with each and every part of the human body i.e., head, face, trunk and extremities³. This relationship helps a forensic scientist to calculate stature from dismembered and mutilated body parts during forensic examinations and thus aids in narrowing down the investigation process by providing useful clues to the investigation agencies. The dental arch has many variables which makes it almost impossible for two people to have identical tooth features⁴. Teeth are special in cases of identification of the deceased since they can resist the effect of time, are resistant to fire and trauma and can also provide information on species, race, gender, age, height and individual characteristics. Teeth have also added the advantage of standard anatomical landmarks which are easy to locate⁵. The literature however is lacking in that the derivation of the height from an odontometric parameter has not been explored adequately.

Carrea conducted studies to estimate height, based on the fact that there is proportionality between the diameter of the teeth and body height and used it to estimate height from the dimensions of the anterior mandibular teeth. Using the measured dimensions of the arch and chord the upper and lower range of the height estimates are derived⁶.

Similar studies conducted by Silva, Sampaio, Cavalcanti & Rekhi have verified this fact^{4,7-11}. Looking at the scarcity of studies pertaining to the estimation of stature from dental dimensions in the Indian scenario, the present study has ventured to provide anthropometric relationships of dimensions of certain teeth with stature based on the Carrea's index (Modified)¹² and to test the validity between two populations of India and to determine if there are sex-wise differences in success rates amongst both the population of India with the statistical aid of regression analysis of the variables obtained.

Materials and Methods

The present study involved a prospective; cross-sectional; survey conducted by the Departments of Oral Pathology and Microbiology and Orthodontics and Dentofacial Orthopedics, Subharti Dental College and Hospital, Swami Vivekanand Subharti University (SVSU), Meerut, Uttar Pradesh, India.

The study was approved by the University Ethical Committee, SVSU and informed consent was obtained from all the volunteers who participated in the study.

Two racial groups (Western Uttar Pradesh and North-East population) served as material for this study. Study subjects were in the age group of 20-25 years and satisfied the inclusion and exclusion criteria.

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Inclusion Criteria

- Complete set of fully erupted, periodontally healthy, noncarious, and satisfactorily aligned mandibular anterior teeth
- No history or clinical evidence of orthodontic and orthognathic treatment

Exclusion Criteria

- Students not falling within the stipulated age limit
- Students belonging from a different ethnicity or geographic area
- Known history of allergy to dental impression materials

A total of 200 volunteers (100 belonging to western Uttar Pradesh and 100 belonging to North-East) satisfying the various inclusion and exclusion criteria were selected amongst the students of various constituent colleges of SVSU.

From the selected study subjects, the following data was obtained;

- a. The stature of the subject (S)
- b. Odontometric measurements: Mandibular cast was made of dental stone from an alginate impression. Carrea's index (Modified) was calculated from the mandibular casts using measurements including arch (A) and chord (C)

The detailed methodology for obtaining the abovesaid data has been tabulated in Table 1. Moreover, diurnal variations in stature have been documented and substantial diurnal variation in stature is known to affect height data in forensic examination. It is proposed to measure the height of an individual at one defined time in a day in humans, to avoid variations in stature estimation¹³. All the measurements were made in the morning between 10 A.M to 12 A.M.

Utmost care was taken while measuring the subjects for stature and the casts for odontometric measurements.

For odontometric measurements, the same brand of alginate (Septodont) and dental stone (Neelkanth) was used throughout the study and adequate care was taken to maintain a standard water-powder ratio of both alginate and dental stone. To avoid inter-observer error, all the dental stone models were measured by a single investigator.

Carrea's Index (Modified) Calculation

Using Arch and Chord values measured, the upper and lower range of height estimates were derived using the formulae:

Maximum stature = $6 \times \prod \times A \times 100/2$

Minimum stature = $6 \times \prod \times C \times 100/2$

The estimated stature in millimetres was converted to centimetres for direct comparison with the actual stature.

Statistical analyses were performed using SPSS Statistics v. 19.0 (IBM, Armonk, NY, USA) for the odontometric dimensions obtained.

Measured feature	Armamentarium used	Methodology
Stature (S) (Figure 1)	Anthropometer	 Subject made to stand on a horizontal platform with → Heels together and to the ground → Stretching upward to full extent → Back as straight as possible → Head adjusted to Frankfurt's horizontal plane → Horizontal arm of anthropometer made in contact with subjects head
Arch (A) (Figure 2)	Mandibular dental cast; Divider caliper	Sum of greatest mesio- distal widths of anterior teeth of one quadrant measured from the labial surface (in mm)
Chord (C) (Figure 3)	Mandibular dental cast; Divider caliper	Direct distance between mesial edge of central incisor and distal edge of canine on one quadrant measured from lingual surface (in mm)

 Table 1. Anthropometric measurements

Odontometric Measurements

Statistical mean (M) and Standard deviation (D) for Arch and Chord values obtained were calculated according to gender. (Table 2) The proportion of correct estimations, when compared to stature according to sex, was determined using the Chi-square test (Table 3). p values of < 0.05 were considered statistically significant. Further, simple linear regression models were created, with actual stature as the outcome variable (y) and estimated stature as the predictor variable (X). Regression lines were constructed as y = a + bx wherein the regression coefficients, a and b were obtained from the regression models. Separate regression equations were constructed for maximum and minimum estimated statures which were gender and population specific.

 Table 2. Descriptive statistics of stature, arch and chord values

Odontometric	Males	Females
measurements (Carrea's index)	Mean±SD	Mean±SD
Actual height (mm)	1699 ± 5.717	1581.667 ± 6.08
Arch (mm)	19.67 ± 0.91	18.20 ± 0.96
Chord (mm)	17.41 ± 0.94	16.43 ± 0.93

 Table 3. Overall distribution of correct and incorrect

 estimations of stature, according to sex and side of the arch

Sex	Side	Correct	Incorrect	P value
Malaa	Right	44 (88 %)	6 (12 %)	0.712
Males	Left	43 (86 %)	7 (14 %)	0.712
Females	Right	46 (92 %)	4 (8 %)	0.00
	Left	45 (90 %)	5 (10 %)	0.009

Results

The analysis of Carrea's index applied to the hemiarches has shown a higher percentage of success in females compared to males for both populations. (Table 3)

On linear regression analysis, the regression equations were derived (Table 4). The linear regression equations were derived for the estimation of stature from Carrea's index in both genders. There was a statistically significant positive correlation between Carrea's index and height in both genders and both populations.

Discussion

5-Various methods are used to establish the identity of unknown remains. The reliability of each method varies. Estimation of stature, as part of the identification process, has a long history in physical anthropology.

Osteometry seems to be the preferred technique because it is more effective in determining sex and race to an extent. However, this cannot be said to be true in the case of teeth where no defined relation between the lengths of teeth exists in relation to body parts and the development of teeth is not directly related to the development of other body parts. Still, the method of using teeth measurements has several advantages as the anatomical landmarks are standard, well defined and easy to locate.

The stature estimation in situations when cephalofacial remains are brought for forensic examination can supplement the other personal identification data like estimation of age, sex, race and identification from facial morphological characteristics as well as peculiar individualistic features^{14–17}.

The dental arch has many variables which makes it almost impossible for two people to have identical tooth features. Teeth are special in cases of identification of the deceased since they can resist the effect of time, are resistant to fire and trauma and can also provide information on species, race, gender, age, height and individual characteristics¹⁸.

As there are differences in odontometric features in specific populations, even within the same population in the historical and evolutional context, it is necessary to determine specific population values in order to make identification possible based on dental measurements. At this juncture, the current study is undertaken to fill this lacuna in two different populations of India

Carrea conducted studies to estimate height, based on the fact that there is proportionality between the diameter of the teeth and body height and used it to estimate height from the dimensions of the anterior mandibular teeth. Using the measured dimensions of the arch and chord the upper and lower range of the height estimates are derived¹⁹. In the current study, actual statures were measured, and males showed high mean actual stature than females in both populations.

Group	Mean actual stature ± SD (cms)	Mean minimum estimated stature ± SD (cms)	Mean maximum estimated stature ± SD (cms)
Western UP Male	171.90 ± 5.717	164.1 ± 0.94	186.7 ± 0.91
Western UP Female	158.16 ± 6.08	153.3 ± 0.93	172.0 ± 0.96
North-East Male	161.05 ± 1.05	153.11± 1.01	169.09± 1.20
North-East Female	150.06 ± 2.01	145.30± 2.02	163.01± 1.10

 Table 4. Mean estimated statures and actual stature of the subjects belonging to Western Uttar Pradesh population and

 North East population

Table 5. Proportions of correct and incorrect estimates for stature according to sex in both populations

Sex	Correct	Incorrrect	P value	
(UP)Males	41 (81.57 %)	09 (14.3 %)	0.712	
(UP)Females	38 (76.5 %)	12 (23.5%)	0./12	
(N-E)Males	42 (84.7 %)	8 (15.3 %)	0.660	
(N-E)Females	37 (73.1%)	13 (26.9 %)	0.009	

When successful and unsuccessful predictions were compared among both genders, a higher percentage of success rate was observed, males showed the highest percentage of correct estimated height. These findings were in accordance with results obtained from Carrea, Lima and Sruthi et al. The findings of the present study indicate that Carrea's index correlated positively and significantly with stature. The present study revealed significant success rate for both males and females^{12,20-22}.

Yadav *et al.*, concluded that regression equation generated from odonotometric parameters can be used as a supplementary approach for the estimation of stature when extremities are not available but with caution as there are population specific and cannot be used on other populations of the world.

In a few earlier studies, two methods of measuring arch and chord were used namely the conventional and the modified method. In the case of the conventional method, the arch was measured using a millimetre tape and the chord was measured using a divider caliper whereas, in the modified method, both were measured using a divider caliper as followed in this study^{23–27}. The

conventional method showed lower success rates for both sexes and both sides¹².

The findings of the present study indicate that Carrea's index correlated positively and significantly with stature. We found that the actual stature of 41% of UP males 42% of NE males and 38% of UP females and 37% NE females could be determined using Carrea's index.

In this study, a modified method was adopted for recording the arch and chord dimensions using a calliper and ruler. The same result was seen on the left and right hemiarches, demonstrating that the method can be applied on both sides, without affecting the outcome. As stated by Carrea, any hemiarch can be used to estimate stature, considering the principle of bilateral symmetry, accepting small variations as normal asymmetries.

This study noted that the minimum estimated stature was closer to the actual stature for most of the subjects.

However, further studies with larger sample sizes and involving multiple ethnic groups are required to estimate the accuracy of this parameter in estimating stature.

Conclusion

The Carrea's index for stature estimation is a convenient, simple and inexpensive method, and can provide valuable information to the forensic investigation when dental remains are present. Further research is warranted with larger samples in the direction of definite improvement in the accuracy of stature estimation.

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How to cite this article: Vandana R., Wadhwan V. and Munish R. Correlation and Estimation of Stature from Carrea's Index: A Study Among Two Populations in India. J Forensic Dent Sci. 2021; 13(2):78-83.

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