Research article

Estimation of stature with the help of tooth length using cone beam computed tomography

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ABSTRACT

Introduction and Aim: Stature is the primary tool in personal identification for forensic and physical anthropology for over a period. In the absence of full skeleton, the stature can be estimated from various skeletal components. Utilizing cranium and dentition measurements is simpler as these structures are fixed, grown and straight forward to locate. Few researches had been undertaken to establish the efficacy of teeth dimensions in height assessment. But we could not come across any such studies on tooth length. So, the present research was conducted to estimate the stature from tooth length using Cone Beam Computed Tomography (CBCT).

Materials and Methods: Tooth lengths of all 4 canines were measured on digital CBCT using inbuilt software Planmeca Romexis® Software (Helsinki, Finland). Height was considered as measurement of length, from the head to toe using standard height chart. Pearson correlation test and linear regression analysis was used as a statistical tool for co-relation co-efficient and population specific formula for height assessment.

Results: There was a very good correlation between tooth length and stature, with r value 0.12-0.81 and p value less than 0.05. The length of the mandibular right canine had better correlation with stature followed by mandibular left canine, maxillary left canine and maxillary right canine. Regression equation was developed from tooth length, to predict stature.

Conclusion: Tooth length measuring using CBCT has a very good correlation with the height of the individual, as it is closer to actual length. Combined data, without sex as a parameter provides more accurate prediction. However, predication accuracy was better in females than males, when gender considered as a parameter in the regression analysis.

Keywords: Stature; tooth length; correlation; cone beam computed tomography.

INTRODUCTION

Estimating stature plays a major role in anthropology and forensic odontology (1). The primary investigation for identification of unidentified skeleton is done by stature assessment. Commonly stature estimates are assessed from bones of extremities and must be used for the identification of cases performed based on skeletal remains (2). Previous researches have shown a good correlation between stature and various skeletal components such as head, extremities and trunk (3-6).

A study by Filipson and Goldson in early 1963 had proven that there was no association between stature and tooth size (7). However, a few other researchers found a moderate to good correlation between stature and inter-canine width and inter-premolar width (8-10). A study by Prabhu et al., on estimating stature from mesio-distal and bucco-lingual measurements found a moderate to good correlation (1).

On the other hand, no such research works on association between height of the individual and tooth length was found during a literature search in English language. Measuring the tooth length in Orthopantomograms (OPG) will result in magnification error which may influence the actual length of the tooth. Hence, this research was undertaken to measure accurate tooth length using CBCT and correlating that with the stature.

MATERIALS AND METHODS

Individuals included in this research were selected from the patients who visited the Department of Oral Medicine and Radiology, Yenepoya Dental College and who are advised to get CBCT for implants, orthodontic correction, or any other treatment purpose. It includes 100 individuals (50 females and 50 males) between the age of 18 and 30 years. The study commenced after obtaining the institutional ethical clearance from ethics committee, Yenepoya (Deemed to be) University. Selected patients were explained about the study and written consent was taken from each participant. Inclusion criteria 1) Participants with all erupted canines. 2) Individuals with canines having appropriate arrangement. Exclusion criteria: 1) Individuals with teeth having decay or any tooth related issues. 2) Participants with
mal-aligned teeth. 3) Individuals with teeth having restoration or RCT, crown and any rehabilitative procedure which will hamper the exact tooth length. 4) Individuals with teeth having physiologic wear such as attrition, abrasion, or erosion.

Height of all the selected subjects was measured using standardized procedure. The subject were asked to position themselves erect and barefooted on a solid flat surface in front of a scale calibrated to 0.1 cm on a firm perpendicular surface. The subjects back should be as straight as possible, which may be achieved by rounding or relaxing the shoulders and manipulating the posture (1).

For tooth measurements while taking the CBCT, the patient’s head should orient in the center of the scan field with the use of lateral laser light marker for positioning. Patient was asked to bite with maximum intercuspation and not to shift their head or tongue during the process. All images had a full field of view so that the entire features were completely recorded. The 3D images were received in DICOM (Digital Imaging and Communication in Medicine) format. The DICOM records were then imported into Planmeca Romexis® Software (Helsinki, Finland) and the tooth length were measured using the Viewer software (Fig. 1). The tooth length was calculated for Canines- starting at the cusp tip to the root apex.

**Statistical tests**

Statistical tests were done using the SPSS software version 17. [Chicago, USA] Pearson correlation test for association between tooth length and height and linear regression analysis was done for the prediction of height from tooth length.

**RESULTS**

Out of four canines, three of them (75%) were having statistically significant (p <0.05) correlation with height with correlation coefficient ‘r’ ranging from 0.12- 0.76. The length of mandibular right canine had better correlation with height, followed by mandibular left canine, maxillary left canine and maxillary right canine. The co-relation was better in females than males, when gender was added as a parameter in linear regression analysis. However, when the data was combined for both male and female, the r value increased up to 0.81 and SEE being 6.3 years. The summary of the results has been tabulated in Table 1-4 and Fig. 2.

![Fig.1: Tooth length measurement of A. Maxillary right canine (13), B. Maxillary left canine (23), C. Mandibular left canine (33) and D. Mandibular right canine (43).](image)

**Table 1: Correlation between height and tooth length(for male-female data separately)**

<table>
<thead>
<tr>
<th>Sex</th>
<th>Tooth length</th>
<th>Pearson correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>TOOTH 13 (mm)</td>
<td>.764*</td>
<td>.000*</td>
</tr>
<tr>
<td></td>
<td>TOOTH 23 (mm)</td>
<td>.623**</td>
<td>.003*</td>
</tr>
<tr>
<td></td>
<td>TOOTH 33 (mm)</td>
<td>.461*</td>
<td>.041*</td>
</tr>
<tr>
<td></td>
<td>TOOTH 43 (mm)</td>
<td>.511*</td>
<td>.021*</td>
</tr>
<tr>
<td>Male</td>
<td>TOOTH 13 (mm)</td>
<td>.128</td>
<td>.591</td>
</tr>
<tr>
<td></td>
<td>TOOTH 23(mm)</td>
<td>.100</td>
<td>.676</td>
</tr>
<tr>
<td></td>
<td>TOOTH 33(mm)</td>
<td>.551*</td>
<td>.012*</td>
</tr>
<tr>
<td></td>
<td>TOOTH 43(mm)</td>
<td>.634*</td>
<td>.003*</td>
</tr>
</tbody>
</table>

* Significant at p<0.05; **p<0.01
Table 2: Correlation between height and tooth length (for combined data)

<table>
<thead>
<tr>
<th>Tooth length</th>
<th>Pearson correlation (Height)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOOTH 13(mm)</td>
<td>.453**</td>
<td>.003*</td>
</tr>
<tr>
<td>TOOTH 23(mm)</td>
<td>.479**</td>
<td>.002*</td>
</tr>
<tr>
<td>TOOTH 33(mm)</td>
<td>.698**</td>
<td>.000**</td>
</tr>
<tr>
<td>TOOTH 43(mm)</td>
<td>.741**</td>
<td>.000**</td>
</tr>
</tbody>
</table>

* Significant at p<0.05; **p<0.01

Table 3: Linear regression analysis for female-male combined data

<table>
<thead>
<tr>
<th>Model</th>
<th>R</th>
<th>R²</th>
<th>SEE</th>
<th>ANOVA testp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.812</td>
<td>0.660</td>
<td>6.389</td>
<td>.0001, HS</td>
</tr>
</tbody>
</table>

Table 4: Linear regression formulæ

<table>
<thead>
<tr>
<th>Linear regression formula generated</th>
<th>Model significance</th>
<th>R²</th>
<th>SEE* (in years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Linear regression analysis for all the subjects without adding gender as a parameter</td>
<td>Height = 71.45 + 1.513 × (length of 13) – 0.577 × (length of 23) + 1.071 × (length of 33) + 2.144 × (length of 43).</td>
<td>&lt;0.05.</td>
<td>62.1%</td>
</tr>
<tr>
<td>Linear regression analysis involving gender as a parameter</td>
<td>Height = 85.97 + 1.406 × (length of 13) – 0.411 × (length of 23) + 0.656 × (length of 33) + 1.728 × (length of 43) + Gender.</td>
<td>&lt;0.05</td>
<td>66%</td>
</tr>
</tbody>
</table>

*SEE – Standard Error of Estimate which is the difference between estimated age and actual age

Fig. 2: Linear regression analysis of combined data for A. Maxillary right canine (13), B. Maxillary Left canine (23), C. Mandibular left canine (33), and D. Mandibular right canine (43)

DISCUSSION

Stature is essential in individual identification for forensic and physical anthropologists (1). Previous studies have shown that height of the individual has an association with the dimensions of various parts of human body such as the cranial and facial bones, long bones, trunk, and foot bones etc., (11-24). However, Height assessment from tooth has hardly ever investigated (1). This research was attempted to see such association between height and tooth length, using Cone Beam Computed Tomography (CBCT), as it provides more accurate tooth length compared to any other radiographic techniques.

Previous studies on correlating stature with hand length, tibial length, head length, cephalo-facial measurements, sternum length, coronal sutures and ulna length showed moderate correlation (r= 0.2-0.5) and SEE of 4.7 -7 years (11-24). However, in the present study stature has a good correlation with the tooth length with p-value less than 0.05 and r value ranging from 0.128 - 0.812 and SEE varying from 6.3-6.6 years.
Yadav et al., (9) in their research measuring the mesio-distal crown width of six maxillary teeth had found a higher value of SEE (8.907) compared to our results (6.3). The study showed that all odontometric parameters were positively and significantly correlated with stature independent of gender, where maxillary canine width showed highest correlation. In the present study, length of the Mandibular right canine had highest correlation among all the teeth.

The combined mesio-distal measurements of all the maxillary anterior teeth were correlated with the height in research by Kalia et al., where they could get a low statistically significant correlation, contrasting to our finding (2).

Stature estimation by both mesio-distal and buccolingual measurements of all the 28 teeth (56 variables) on Indian Population was carried out by Prabhu et al., where they found a statistically significant but moderate correlation with R value being 0.68 (1).

In the present study, canine was selected for analysis considering it as a tooth which rarely affected by caries and last tooth to be lost. In addition to that, canine was always considered in most of the forensic studies as it has the better prediction accuracy. In this study, there was a better correlation between tooth dimension and height with r value 0.76 – 0.812, though having little higher SEE of 6.653cms compared to the previous study using OPGs (r = 0.12-0.57 and SEE = 4.1-5.5 years) (25). It might be because all the 28 teeth were considered in that study and probably CBCT of all the teeth may still improve the correlation co-efficient and reduce the SEE.

In this study, a regression formula was developed with all the four teeth entering the formula, such as maxillary right canine, maxillary left canine, mandibular right canine and mandibular left canine. When the data was analyzed for males and female gender separately, then also all the 4 teeth entered the linear regression formula generated.

CONCLUSION

Height of the individual is a major factor in determining the partial identity of the damaged bodies and skeletal remains. Since CBCT measurements of teeth gives more accurate tooth length compared to other radiographic methods (because of lesser magnification error), the tooth length here can be considered as closest to the actual tooth length. In this study, 3 out of 4 variables had a significant correlation with stature, which accounts up to 75%. All the 4 canines entered regression formula having co-relation co-efficient ranging from 0.76-0.82, which is an excellent co-relation. However, SEE was little higher which was up to 6.3-6.6 cms, which can be attributed to using only 4 teeth. So, involving all the teeth and more sample size may provide us better accuracy in predicting stature from tooth length using CBCT. These results indicate that tooth length can be used as the tool in stature estimation.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

REFERENCES


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