Physical height and crown dimensions of primary teeth: A dental morphometric study in Saudi Arabian children

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Abstract

Background: Teeth morphometrics have been considered to be integral in identifying an individual as it is correlated with the body stature.

Aim: The aim of the study was to determine the association between crown length and physical height of children and derive mathematical equations for the prediction of physical height from crown length of primary maxillary anterior teeth.

Setting and Design: A dentomorphometric study was carried out among 100 Saudi Arabian children of 3–6 years of age. Maxillary arch impressions were taken for all participants. Clinical crown length and physical height were measured using digital Vernier Caliper and Physician Mechanical Beam Scale, respectively. Regression analysis, correlation analysis and unpaired *t*-test were performed for data analysis.

Results: In female children, a statistically significant moderate positive correlation between primary maxillary right lateral incisor and primary maxillary left central incisor and height of the children, and highly significant association between primary maxillary left lateral incisor and height of the children was found. Whereas for male children, there was a significant moderate positive correlation between primary maxillary right central incisor, primary maxillary right canine and primary maxillary left central incisor with physical height of children.

Conclusions: The research has established a significant positive correlation between the clinical crown length and the height of the children in combined sample for teeth numbers 51, 52, 53, 61 and 62. The study has derived the mathematical equations for the prediction of physical height from crown length of few maxillary anterior teeth, for both male and female children.

Clinical Significance: The estimation of physical height from the tooth-crown dimensions can prove to be quite beneficial aid in forensic investigations as teeth are resistant to huge traumatic forces such as in case of mass disasters.

Keywords: Children, crown length, height, primary teeth, stature

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Submitted: 04-Oct-2021, **Revised:** 06-Dec-2021, **Accepted:** 17-Dec-2021, **Published:** 31-Mar-2022

Access this article online	
Quick Response Code:	Website: www.jomfp.in
	DOI: 10.4103/jomfp.jomfp_357_21

How to cite this article: Alasmari FS, Ain TS, Togoo RA, Mallawi GZ, Almoghamer AD, Alshikh AA. Physical height and crown dimensions of primary teeth: A dental morphometric study in Saudi Arabian children. J Oral Maxillofac Pathol 2022;26:108-15.

INTRODUCTION

Dental morphometrics is a spectrum of research and analysis that involves the study of tooth dimensions and characteristics such as shape and size. Investigations on teeth form an essential source of clinical study since teeth are widely used in the identification of a person during medicolegal issues.[1] It has been reported in the literature that large teeth usually correspond to larger jaws and body.[2] There lies a significant association of the tooth dimensions with the size of a body. Teeth morphometrics have been considered to be integral in identifying an individual as it is correlated with the body stature. Tooth shape and size are prominently associated with the body structure. Various academic studies have been investigated in a determined effort of identifying physical height as a factor in using permanent tooth morphometrics in the past.[3]

However, there are discrepancies in the current body of knowledge where few studies[4,5] have found no association between the body structure and tooth morphometrics, while other researchers[6] have found some significant correlation between body height and multiple dimensional parameters of the incisor tooth. Different parameters such as ethnic and racial differences[7] as well as different study designs, methods of measurement and different age-groups of study population have caused such discrepancies and varied results in the literature.

In Saudi Arabia, the paucity of studies evaluating the association between primary anterior teeth crown-lengths and physical height of children exists and hence necessitates the need to investigate the association between physical height and primary teeth dimensions.

Teeth have been considered as a relevant source of study material for both living as well as nonliving individuals, thereby constituting a significant role in various fields such as genetics, anthropological, odontogenic and forensic investigations.[1] United Nations Declaration of Human Rights states that every freeborn person has the right to be identified even after death.[8] Bones and teeth are considered to be highly resistant and indestructible as these combat bacterial degradation, while other tissues get putrefied easily.[9] Teeth thus play a vital role in individual recognition or finding unknown identity from skeletal remains in various disasters.[10,11] If the relationship of tooth dimensions to stature is further ascertained, it would add to the success of forensic investigations.

As observed in literature, research has been carried out to explore the relationship between body stature and permanent teeth dimensions of anterior teeth and less mention about primary teeth has been made in previously, hence the present study was undertaken to find and evaluate the association, if any, between the primary maxillary anterior teeth crown-lengths and height of Saudi Arabian children. The study further evaluates the mathematical equation for the prediction of physical height from crown length of primary maxillary anterior teeth.

MATERIALS AND METHODS

A dento morphometric study was carried out at the department of Pediatric Dentistry and Orthodontic Sciences, King Khalid University College of Dentistry, Saudi Arabia. The cross-sectional study consisted of children aged 3–6 years. Before the conduct of the study, ethical clearance was obtained from the Scientific Research Committee, King Khalid University (letter Reference#IRB/KKUCOD/ETH/2019-20/030).

Inclusion criteria

- Children having fully erupted teeth # 51, 52, 53, 61, 62 and 63 with healthy state of gingiva and periodontium
- Children with no crowding or inter-dental spacing between teeth
- 3–6-year-old children.

Exclusion criteria

- Children having incompletely erupted or mobile primary teeth and apparent loss of tooth structure due to fracture, attrition or dental caries
- Children below the age of 3 years and above the age of 6 years.

Sample size estimation

Sample size was estimated by the formula: $N = ([Z_\alpha + Z_\beta]/C)^2 + 3$

Threshold probability for rejecting the null hypothesis, Type I error rate, α (two-tailed) = 0.05.

Probability of failing to reject the null hypothesis under the alternative hypothesis, Type II error rate, $\beta = 0.20$.

The expected correlation coefficient from pilot study, $r = 0.277$.

The standard normal deviate for $\alpha = Z_\alpha = 1.9600$.

The standard normal deviate for $\beta = Z_\beta = 0.8416$.

$C = 0.5 \times \text{In}([1 + r]/[1 - r]) = 0.2844$

Total sample size = $N = ([Z_\alpha + Z_\beta]/C)^2 + 3 = 100$

A sample of 100 children fulfilling the inclusion criteria, participated in the study. Informed written consent was taken from the parents/guardians of the participants. Fadwa SA (FSA) and Ghadah ZM (GZM) did the measurement of physical height and tooth-crown height of the subjects. Maxillary arch impressions using irreversible hydrocolloid (alginate) impression material (Jeltrate, Dentsply, Petropolis, RJ, Brazil) were taken, dental casts were prepared using dental stone (Durone IV, Dentsply, Petropolis, RJ, Brazil) [Figure 1] for all the subjects, and clinical crown length was measured on study casts using digital Vernier Caliper (Digimatic caliper, Mitutoyo, UK) for teeth # 51,52,53,61,62, 63 [Figures 2 and 3].

Standardization of digital vernier caliper

It was done according to ISO-13385-1 standard. According to this standard, at least 5 measuring points have to be checked. The caliper was set at Zero and then a 20 mm Guage-block was taken to execute two checks; one on the measuring point as close as possible to the measuring rail of caliper and another one on a measuring point as far as possible from the measuring rail. Next, a 50 mm gauge-block was taken to perform a check at the center of measuring area. Then, 4th and 5th points had to be checked, for which a guage block that was at least 90% of the total measuring range of the caliper was used (we used 150 mm guage block). Using this block, two measurements were performed; one was done as close as possible to the measuring rail and another one was done as far as possible from the rail. This completed our 5-point measurement checks for the digital vernier-caliper calibration.

The height of all children was measured and recorded by Physician Mechanical Beam Scale with Height Rodand (Detecto Scales, Missouri, China). The inter- and intra-examiner reliability was assessed using Cohen Kappa statistics and was found to be 0.73 (substantial; $P = 0.12$) and 0.82 (almost perfect; $P = 0.11$), respectively. Two examiners (FSA and GZM) were the dental interns who were calibrated during pilot study by well-trained experts wherein 20 subjects were selected before conducting the main study.

The data were subjected to statistical analysis using the Statistical Package for the Social Sciences version 20.0 software (SPSS 20, IBM, Armonk, NY, United States of America). Pearson's correlation, unpaired *t*-test and a step-wise linear Regression Analysis were applied for statistical analysis of data.

RESULTS

The normality of data was tested by Shapiro–Wilks test and found normally distributed. The correlation coefficient, coefficient of determination (R^2) and adjusted R^2, for height and age as dependent variables and crown length as independent variable, were calculated. To predict height, a step-wise linear forward regression method was used, in which height was dependent variable and crown length was independent variable. The significance of regression coefficient was tested by *t*-test and level of significance was set at 5% ($P < 0.05$).

Figure 1: Dental cast preparation

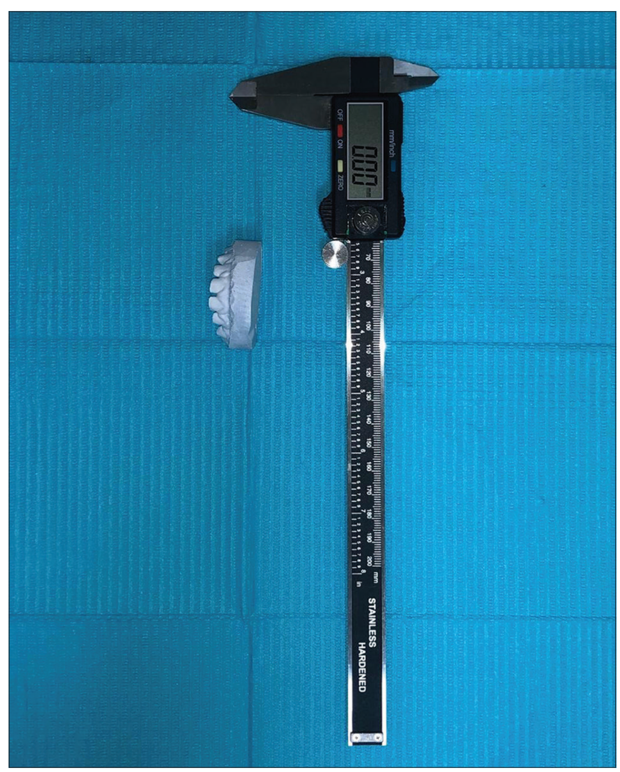


Figure 2: Digital vernier caliper

Out of the total 100 subjects, 56 were males and 44 were females. The subjects' age ranged from 3 to 6 years with a mean age of 5.10 and 5.04 among male and female children, respectively [Table 1]. The results revealed that the mean value of the physical heights (in cm) of male and female children was 111.07 ± 6.12 and 109.66 ± 6.87, respectively [Graph 1]. The mean crown heights (in mm) in male children with respect to tooth # 51, 52, 53, 61 62 and 63 were found to be 5.3 (±0.688), 4.7 (±0.655), 5.8 (±0.582), 5.3 (±0.651), 4.5 (±0.452) and 5.6 (±0.603), respectively, while for females, it was 5.2 (±0.547), 4.7 (±0.614), 5.7 (±0.597), 5.2 (±0.541), 4.5 (±0.592) and 5.7 (±0.559), respectively [Graph 2]. The comparison of height, clinical crown length and crown length/height ratios among males and females using unpaired *t*-test are shown in Table 2. There was no significant difference between males and females clinical crown length and crown length/height ratios.

In combined samples, tooth number 51, 52, 53, 61 and 62 shows a significant positive correlation between the clinical crown length and the height of the child. In male samples, tooth number 51, 53 and 61 shows significant moderate positive correlation and tooth number 52 shows high positive correlation between the clinical crown length and height of the child. In female samples, tooth number 52, 61 and 62 shows moderate positive correlation of clinical crown length and height of the child [Table 3].

Using regression analysis [Table 4a,-c], the study derived a mathematical equation for the prediction of physical height from crown length of few maxillary anterior teeth, for combined sample as well as male and female sample.

The equation derived from male data for male child height prediction using Primary Maxillary right central incisor crown length:

Height = 92.940 + 3.394 × (Primary Maxillary right central Incisor CL) ± SE

The equation derived from combined (males + females) data for child height prediction using Primary Maxillary left central Incisor crown length:

Table 1: Mean age of male and female subjects

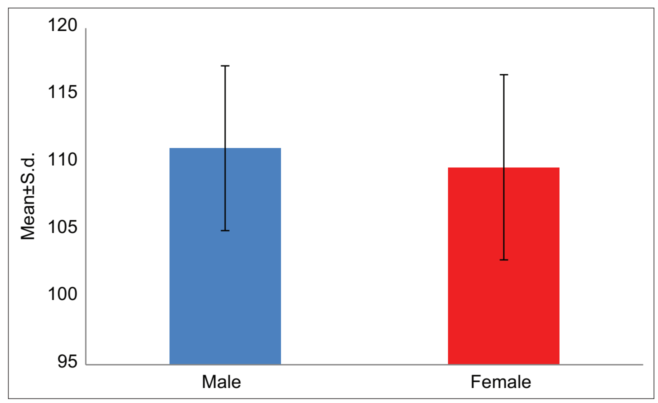
	Group statistics				
	Gender	*n*	Mean age	SD	SEM
Age	Male	44	5.104	0.6331	0.0954
	Female	56	5.045	0.6413	0.0857

SD: Standard deviation, SEM: Standard error of mean

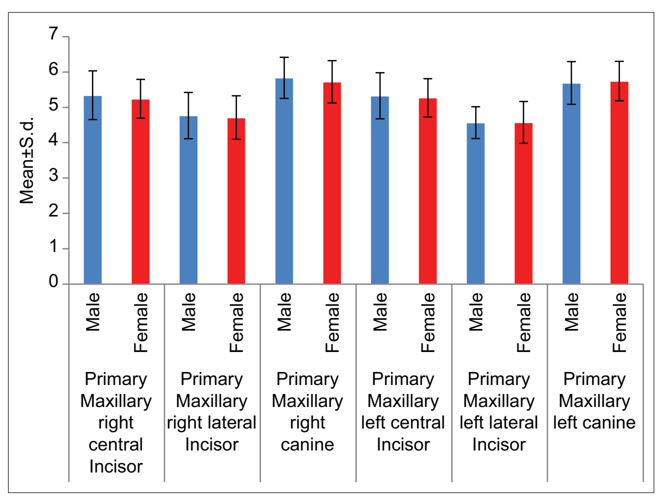
Height = 90.078 + 3.815 × (Primary Maxillary left central Incisor CL) ± SE

The equation derived from female data for female child height prediction using Primary Maxillary left lateral Incisor crown length:

Figure 3: Measurement of tooth crown-height using digital vernier caliper



Graph 1: The mean values (± standard deviation) of physical heights of male and female subjects



Graph 2: Mean values (± standard deviation) of crown-lengths of maxillary anterior teeth of male and female subjects

Table 2: Comparison of height, clinical crown length and ratios of crown length/height among males and females using unpaired *t*-test

	Gender	*n*	Mean	SD	SEM	Mean difference	*P*
Height	Male	44	111.07	6.120	0.923	1.407	0.289 (NS)
	Female	56	109.66	6.876	0.919		
Primary maxillary right central incisor	Male	44	5.341	0.6885	0.1038	0.1026	0.421 (NS)
	Female	56	5.239	0.5474	0.0731		
Primary maxillary right lateral incisor	Male	44	4.766	0.6534	0.0985	0.0556	0.663 (NS)
	Female	56	4.711	0.6140	0.0820		
Primary maxillary right canine	Male	44	5.833	0.5820	0.0877	0.1087	0.363 (NS)
	Female	56	5.724	0.5974	0.0798		
Primary maxillary left central incisor	Male	44	5.326	0.6513	0.0982	0.0564	0.381 (NS)
	Female	56	5.270	0.5414	0.0723		
Primary maxillary left lateral incisor	Male	44	4.567	0.4527	0.0683	−0.0067	0.651 (NS)
	Female	56	4.574	0.5922	0.0791		
Primary maxillary left canine	Male	44	5.690	0.6032	0.0909	−0.0501	0.669 (NS)
	Female	56	5.741	0.5596	0.0748		
CL/H 51	Male	44	0.0433	0.00611	0.00092	−0.00150	0.451 (NS)
	Female	56	0.0448	0.01192	0.00159		
CL/H 52	Male	44	0.0483	0.00616	0.00093	−0.00165	0.474 (NS)
	Female	56	0.0500	0.01424	0.00190		
CL/H 53	Male	44	0.0528	0.00531	0.00080	−0.00168	0.451 (NS)
	Female	56	0.0545	0.01395	0.00186		
CL/H 61	Male	44	0.0482	0.00585	0.00088	−0.00200	0.353 (NS)
	Female	56	0.0502	0.01319	0.00176		
CL/H 62	Male	44	0.0414	0.00461	0.00070	−0.00209	0.266 (NS)
	Female	56	0.0435	0.01172	0.00157		
CL/H 63	Male	44	0.0515	0.00559	0.00084	−0.00312	0.1632 (NS)
	Female	56	0.0546	0.01385	0.00185		

CL: Crown length, H: Height, SD: Standard deviation, SE: Standard error, NS: Not significant

Table 3: Correlation between clinical crown length and height by using Pearson's correlation co-efficient in combined samples (males+females), males and females

	Combined	Male	Female
Age			
Pearson correlation	0.455**	0.569**	0.374**
P	0.000	0.000	0.005
Primary maxillary right central incisor			
Pearson correlation	0.295**	0.382*	0.215
P	0.003	0.011	0.111
Primary maxillary right lateral incisor			
Pearson correlation	0.293**	0.229	0.338*
P	0.003	0.134	0.011
Primary maxillary right canine			
Pearson correlation	0.281**	0.300*	0.256
P	0.005	0.048	0.057
Primary maxillary left central incisor			
Pearson correlation	0.343**	0.376*	0.318*
P	0.000	0.012	0.017
Primary maxillary left lateral incisor			
Pearson correlation	0.281**	0.069	0.398**
P	0.005	0.658	0.002
Primary maxillary left canine			
Pearson correlation	0.174	0.190	0.174
P	0.083	0.218	0.199

*Significant $P<0.05$, **Highly significant $P<0.01$. NS: Not significant $P>0.05$

Height = 88.530 + 4.620 × (Primary Maxillary left lateral Incisor CL) ± SE

DISCUSSION

In forensic sciences, age and gender are the important parameters when applied to investigate a deceased individual. At times, height also plays an important role in personal identification. However, in certain cases of decomposed or mutilated bodies, it becomes difficult to determine the identification of a person. Some structures in the orofacial region are resistant to decomposition and hence can be used for stature estimation. Teeth are nondestructive and hence can be used for identification. The present cross-sectional study was carried out to assess the correlation of crown-length of primary maxillary teeth and height of subjects.

In female children, there was a significant moderate positive correlation between primary maxillary right lateral incisor and primary maxillary left central incisor (with $P < 0.05$) with the respective height of the children and highly significant association between primary maxillary left lateral incisor and the height of the children. Whereas for male children, there is a significant moderate positive correlation between primary maxillary right central incisor, primary maxillary right canine and primary maxillary left central incisor with their physical height. These findings are similar to several studies previously conducted in the existing volume of literature. When compared to a study by Hinduja *et al.*,[6] it was found that there exists a clear correlation between the mesiodistal width of the maxillary anterior teeth and the height of a person (student). Another study by Reddy *et al.*[2] reported that, in the sample of females and males between 20 and 50 years of age, there was a conclusive association between the roots of molar and premolars and the body stature of the participants. Similar to the current study, these researches have also drawn a conclusion that a concrete relationship between teeth dimensions and physical height of a person exists. Sruthi *et al*.[12] evaluated a correlation between the anterior mandibular tooth dimensions with that of real stature of the study participants. They found that there was an evident correlation between the stature and crown length, especially in the cases of male subjects. Jani *et al*.[13] also found that there lies a significant correlation between height and maxillary intercanine width.

Few researches produced contrasting results when compared to our results, in determining the correlation between stature and tooth dimensions. A study by Raghavendra *et al*.,[4] aimed to evaluate the height of clinical crown of maxillary central incisor and the body height of the study participants, however, in contrast to the current results, the researchers found no statistical correlation between total crown length and respective body height. Jayawardena *et al*.[5] found no significant correlation between stature and tooth lengths of incisors, thereby determining that genetic linkage between tooth size and stature was weak. A well-renowned study by Sterrett *et al*.[14] did not provide definite correlations between the height of the individual and height of the tooth (crown length). Nevertheless, the study did find internal statistical correlations between male and female heights and the width/length ratios. This revelation is in contrast to the current study, where no significant difference between males and females clinical crown length and crown length/height ratios was found. A study by Islam *et al*.,[15] against the results arrived at by Sterrett *et al*.,[14] found that the length/height ratios between male and female had no significant variance. This finding aligns with our research, wherein no pertinent differences were observed.

The current results revealed that the mean value of the physical heights of male and female children was

Table 4a: Statically significant group of teeth - model summary table

Model summary					
Sex	Model	R	R^2	Adjusted R^2	SE of the estimate
Combined	1	0.343[a]	0.118	0.109	6.193
Male	1	0.382[b]	0.146	0.125	5.724
Female	1	0.398[c]	0.158	0.143	6.367

[a]Predictors: (Constant), primary maxillary left central incisor, [b]Predictors: (Constant), primary maxillary right central incisor, [c]Predictors: (Constant), primary maxillary left lateral incisor. SE: Standard error

Table 4b: Statically significant group of teeth - coefficients table

Coefficients[a]							
Sex		Model	Unstandardized coefficients		Standardized coefficients	t	P
			B	SE	β		
Combined	1	Constant	90.078	5.622		16.023	0.000
		Primary maxillary left central incisor	3.815	1.055	0.343	3.616	0.000
Male	1	Constant	92.940	6.826		13.615	0.000
		Primary maxillary right central incisor	3.394	1.268	0.382	2.677	0.011
Depen female	1	Constant	88.530	6.684		13.245	0.000
		Primary maxillary left lateral incisor	4.620	1.450	0.398	3.187	0.002

SE: Standard error

Table 4c: Statistically insignificant group of teeth - excluded variables table

Gender	Excluded variables[a]						
		Model	Beta in	t	P	Partial correlation	Collinearity statistics
							Tolerance
Combined	1	Primary maxillary right central incisor	−0.051[b]	−0.243	0.809	−0.025	0.207
		Primary maxillary right lateral incisor	0.079[b]	0.539	0.591	0.055	0.426
		Primary maxillary right canine	0.092[b]	0.718	0.475	0.073	0.551
		Primary maxillary left lateral incisor	0.110[b]	0.904	0.368	0.091	0.614
		Primary maxillary left canine	−0.004[b]	−0.037	0.970	−0.004	0.733
Male	1	Primary maxillary right lateral incisor	−0.125[c]	−0.579	0.566	−0.090	0.443
		Primary maxillary right canine	0.076[c]	0.388	0.700	0.060	0.540
		Primary maxillary left central incisor	0.146[c]	0.345	0.732	0.054	0.116
		Primary maxillary left lateral incisor	−0.321[c]	−1.735	0.090	−0.261	0.568
		Primary maxillary left canine	0.047[c]	0.299	0.766	0.047	0.846
Female	1	Primary maxillary right central incisor	−0.024[d]	−0.158	0.875	−0.022	0.662
		Primary maxillary right lateral incisor	0.095[d]	0.507	0.614	0.069	0.450
		Primary maxillary right canine	0.060[d]	0.405	0.687	0.055	0.714
		Primary maxillary left central incisor	0.122[d]	0.774	0.442	0.106	0.636
		Primary maxillary left canine	−0.045[d]	−0.307	0.760	−0.042	0.729

[a]Dependent variable: Height, [b]Predictors in the model: (Constant), primary maxillary left central incisor, [c]Predictors in the model: Constant, primary maxillary right central Incisor, [d]Predictors in the model: (Constant), primary maxillary left lateral incisor

111.07 ± 6.12 and 109.66 ± 6.87 (in cm), respectively. The mean crown heights in male children with respect to tooth # 51, 52, 53, 61 62 and 63 were found to be 5.3, 4.7, 5.8, 5.3,4.5 and 5.6 mm, respectively, while for females, the corresponding values were 5.2, 4.7, 5.7, 5.2, 4.5 and 5.7 mm. A study by Savla *et al*.[16] found that mean heights of the crown in male patients with respect to tooth number 51, 52, 53, 54 and 55 stood at 5.89, 4.77, 5.94, 4.55 and 4.18 respectively. However, the mean of heights of the individuals was found to be 942.84 mm. The mean height of crown in females was 5.02, 4.53, 5.31, 4.76 and 4.68, respectively, while their mean height was found to be 1001.77 mm. These results are along similar lines to the values for mean crown heights of male and female subjects in the current study.

Using linear regression analysis, our study has derived a mathematical equation for the prediction of physical height from crown length of maxillary anterior teeth, for both and male and female children. Our mathematical equation derived for combined (males and females) is 90.078 + 3.815 × (primary maxillary left central incisor CL); for males is 92.940 + 3.394 × (primary maxillary right central incisor CL) and for females is 88.530 + 4.620 × (primary maxillary left lateral incisor CL). The three sets of data (combined [male + female], male only and female only) are used separately during different situations such as equation derived for male data would be used in male height prediction, female data equation derived would be used in female height prediction and combined group data equation derived would be used when the gender of the individual is unknown. When compared to the results reported in relevant literature, Chandrappa *et al*.[17] also used regression analysis for deriving mathematical equations for prediction of physical height in children. They derived equation for combined data for male and female children as 400.558 + 90.264 × (#53 CL); for male children 660.290 + 72.970 × (#55CL) and for female children 187.942 + 194.818 × (#52 CL). The variations in the derived constants would be attributed to the difference in sample size involved in different studies. Sruthi *et al*.[12] used Carrea's index for prediction and reported that, when successful and unsuccessful predictions were compared among both males and females, a higher percentage of success rate was observed, though males showed the highest percentage of correct estimated height.

Limitations of the study

1. Only lengths of crowns of anterior maxillary teeth were considered in the present study
2. The applicability of the study is limited to the selected age group only and is population-specific
3. Different ethnic groups could not be involved to have more comparisons.

CONCLUSIONS

Based on the study results, the research has established a significant positive correlation between the clinical crown length and the height of the children in combined samples (male and female) for teeth numbers 51, 52, 53, 61 and 62. In female samples, moderate positive correlation between clinical crown length of certain teeth and height of the children, while in male samples, highly significant positive correlation between the clinical crown length of tooth # 52 and height of the children was found.

Within the limitations, the findings of the study can be used for prediction of height using the derived equations if the crown lengths are known, especially in forensic/investigative purpose among children. Hence, it can narrow the search of missing persons in disaster management cases as well as assist in identification in medicolegal cases. However, further studies with larger sample size and involving multiple ethnic groups are required to estimate the accuracy of clinical crown length in determining the physical height.

Significance of the research in Forensic aspect

Due to increase in natural/manmade calamities such as floods, earthquakes and accidents, the demand for identification of human remains through forensic investigations has also amplified. No doubt the DNA analysis is a precise way for performing such investigations, but its cost and required facilities become the barriers for some developing countries. Hence, utilizing the other cost-effective ways may be an affordable option.

Teeth being resilient to postmortem damage, hence the relation of tooth size and physical height of the victim would offer a promising clue for identification in cases of juvenile population. In addition, the gender identification would be predicted in postmortem cases as the tooth size varies in male and female children; size being affected by various factors such as environment, culture, race and genetics. Dentomorphometrics may assist in initial screening in cases of medicolegal cases as well.

Future Prospects

The future studies involving large sample size and wide age range of participants and different ethnic/cultural backgrounds should be planned to have more definite insight of the association of physical height and teeth size so that the validity of outcome of such research would be increased and applied for larger population groups.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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