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Prediction of space available for unerupted permanent canine and premolars in a Bangladeshi population

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ABSTRACT

Objective: To test the use of Moyers prediction method and Tanaka and Johnston's equations for use in a Bangladeshi population and to construct new probability tables and prediction formulae based on the actual tooth sizes in a sample of the Bangladeshi population.

Design of the study: Descriptive cross-sectional study.

Materials and Methods: The sample was consisted of 50 Bangladeshi males and 50 females aged between 17 and 23 years. Subjects without any previous orthodontic treatment fully erupted permanent teeth and with no dental anomalies were recruited. Dental study models were taken and measurements of the mesio-distal widths of teeth were carried out using digital caliper. The measured values were compared with predicted values derived from Moyers method and Tanaka and Johnston equations. Independent t tests were used to examine differences between genders. Correlation coefficients and linear regression equations were used to compare the actual Bangladeshi tooth widths with predicted values.

Results: For Bangladeshi males, Moyers method at 50% tends to overestimate the actual value of the canines and premolars by 0.3 mm with a standard deviation of 0.08 mm, whereas the Tanaka and Johnston method tends to overestimate the actual value of the canines and premolars by 1.4 mm with a standard deviation of 0.11 mm.

For Bangladeshi females, Moyers method at 50% tends to overestimate the actual value of the canines and premolars by 0.6 mm with a standard deviation of 0.12 mm, whereas the Tanaka and Johnston method tends to overestimate the actual value of the canines and premolars by 1.4 mm with a standard deviation of 0.13 mm.

Conclusion: The newly developed regression equations are more accurate for prediction of width of unerupted permanent teeth in a Bangladeshi population. Further studies are required based on larger sample size, to confirm the applicability of the new regression equations proposed.

Key words: Dental, space prediction, Bangladeshi (Bangladesh Journal of Orthodontics and Dentofacial Orthopedics October 2012, Vol. 3, No. 1, p 8-16)

INTRODUCTION

An accurate space analysis is an important part of orthodontic treatment planning [1–3] and one aspect of a space analysis in the mixed dentition might be the prediction of future space requirements. The common methods used for space analysis and predictions are

- direct measurement of teeth from study models; [4,5]
- measurement of tooth size using radiographs; [6-8] or
- a combination of the two techniques. [9-11]

Most authors suggest that a combination of methods is more accurate than one technique [12,13] .The reliability of the radiographic method depends on several factors such as technique sensitivity, accuracy of measurement and whether the teeth are rotated in their crypts.[14] Due to concerns about radiation protection radiographic methods may be less frequently used. Also in some developing country, such as Nepal, there may be limited availability of dental radiographic machines.[15]

There are variations in permanent tooth sizes among different ethnic groups and for this reason; the application of non-radiographic approaches has been questioned.[16-19] Other

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variations can occur due to environmental factors,[20] heredity[21] gender differences [4] and bilateral asymmetry.[22,23]

RATIONALE OF THE STUDY

Several studies have been conducted to evaluate the accuracy of the Tanaka and Johnston and Moyer's probability tables in non-white populations. The populations studied include Black South African,[16] Asian- American,[10] Saudi Arabian,[18] Thai,[30] Jewish-Israeli,[31] Syrian,[32] Senegalese,[33] Peruvian,[34] Jordanian[35] and Chinese.[36] All the investigators concluded that neither direct nor radiographic measurements accurately predicted tooth size when applied to non-white groups. But in Bangladesh, no such study has been made to evaluate in our context.

Thus it is necessary to develop a Bangladeshi prediction equation in order to carry out an accurate space analysis in this population.

OBJECTIVES OF THE STUDY

The objectives of this study are to:
• test the correlation between the predicted and actual mesio-distal widths of the unerupted maxillary and mandibular permanent canine and premolars using the total mesio-distal width of mandibular four permanent incisors.
• construct new probability tables and prediction formula based on the tooth size of a Bangladeshi population.
• compare the reliability of the new prediction values against those of the most commonly used values (Moyers[4] and Tanaka and Johnston[5]).

MATERIALS AND METHODS

The study was approved by ethical committee of Dhaka Dental College and Hospital (Ref. memo no.923, Date: 02 June 2011). A convenience sample was obtained consisting of students of Dhaka Dental College and the study was carried out in the department of Orthodontics and Dentofacial Orthopedics, Dhaka Dental College and Hospital, Mirpur-14, Dhaka-1206, Bangladesh. Informed consent was obtained from each subject to take part in the study. A total of 5 dentists were involved in the screening of the subjects and all were trained for 5 days at the outpatient department of Orthodontics at DDCH prior to the data collection.

The inclusion criteria were native Bangladeshi phenotypical characteristics such as brown skin color, black hair and eye color ranging from brown to black, age ranging from 17 to 23 years and all permanent teeth erupted (except third molar). The exclusion criteria were subjects with proximal or occlusal wear, interproximal caries or restorations, crowding, spacing or diastema, any cross bite, any over retained deciduous tooth, missing permanent tooth, deep carious tooth, any hypoplasia or dental anomalies and any past history of orthodontic treatment.[31,32]

Alginate impressions were taken at Dhaka Dental College and Hospital (DDCH) and immediately cast in dental plaster. Measurements were carried out directly from the study models using a Digital caliper (0–150 mm, 799A-6/150, China accuracy of ±0.01 mm).

The mesio-distal dimensions of the following teeth were measured: the mandibular permanent incisors, the mandibular and maxillary permanent canines and the mandibular and maxillary first and second premolars. All measurements were made by a single investigator. A maximum number of 10 pairs of casts were measured per day to avoid fatigue. All measurements were taken perpendicular to the long axis of the tooth with the calliper beak entering the interproximal area from the buccal or occlusal side.[37] The maximum mesio-distal width of each tooth was measured and recorded to 0.1 mm. Repeat measurements were performed after 2 weeks to minimize the possibility of error. Intra-examiner reliability was predetermined as 0.2 mm.[17, 23] If the variation in the repeat measurements was greater than 0.2 mm a third measurement was taken. Repeat measurements that varied by 0.2 mm or less were averaged.

Procedures of Data collection and processing

Data was collected from data record sheets on which mesio-distal dimensions of teeth were recorded. These were entered in a personal computer using the SPSS (statistical package for social science) software.

DATA ANALYSIS

Descriptive statistical analyses were carried out which included calculation of the mean values, standard deviation and ranges. All prediction methods used in this study were based on an average of both sides of the arch. Before combining the data a paired t test was performed and no statistically significant differences were found between the right and left sides. An independent t test was performed to compare the tooth sizes between genders. The significance level was set at $P<0.05$. Correlation coefficients (r) and linear regression equations were formulated to express the relationships between the sum of the mesio-distal widths of the four mandibular incisors (x) and the sum of the mandibular and maxillary arch canines and premolars (y).

The constants a and b in the linear regression equation (y=a+bx), coefficient of determination (r^2) and the standard error of estimate (SEE) were calculated for male, female and both sexes in combination. The data derived from the present study were used to frame prediction equations and to compare with Moyers prediction method and Tanaka and Johnston equations. All statistical analyses were performed using Stata software (version 10.0) in Surveillance & Data Resource Unit, Health System & Infectious Diseases Division (HSID), ICDDR, B.

RESULTS

After an initial screening and with fulfilling the inclusion criteria, an equal sample size of male and females 50 subjects for each gender (total 100) were selected to take part in the study. Descriptive statistical analyses were carried out which included calculation of the mean values, standard deviation and ranges. All prediction methods used in this study were based on an average of both sides of the arch. Before combining the data a paired t test was performed and no statistically significant differences were found between the right and left sides. An independent t test was performed to compare the tooth sizes between genders. The significance level was set at $P<0.05$. Correlation coefficients (r) and linear regression equations were formulated to express the relationships between the sum of the mesio-distal widths of the four mandibular incisors (x) and the sum of the mandibular and maxillary arch canines and premolars (y). The constants a and b in the linear regression equation (y = a+bx), coefficient of determination (r^2) and the standard error of estimate (SEE) were calculated for male, female and both sexes in combination.

The data derived from the present study were used to frame prediction equations and to compare with Moyers prediction method and Tanaka and Johnston equations.

Table 1: Distribution of difference between right and left side (P is the result of the independent t test n=50 for each gender)

Tooth group	Mean(mm)	SD(mm)	95%CI	P-value
Upper Right Canine(UR3)	7.5	0.42	748-7.64	0.5799
Upper Left Canine (UL3)	7.5	0.41	7.47-7.64	
Upper Right First Premolar (UR4)	6.7	043	6.64-6.81	0.1603
Upper Left First Premolar (UL4)	6.7	0.43	6.63-6.80	
Upper Right Second Premolar (UR5)	6.3	0.42	6.22-6.39	0.8393
Upper Left Second Premolar (UL5)	6.3	0.42	6.22-6.39	
Lower Right Central Incisor (LR1)	5.2	0.40	5.18-5.34	0.6604
Lower Left Central Incisor (LL1)	5.2	0.36	5.18-5.32	
Lower Right Lateral Incisor (LR2)	5.7	0.36	5.67-5.82	0.1810
Lower Left Lateral Incisor (LL2)	5.7	0.36	5.68-5.82	
Lower Right Canine (LR3)	6.6	0.40	6.54-6.70	0.0609
Lower Left Canine (LL3)	6.6	0.40	6.55-6.71	
Lower Right First Premolar (LR4)	6.7	0.45	6.69-6.87	0.889
Lower Left First Premolar (LL4)	6.7	0.44	6.70-6.87	
Lower Right Second Premolar (LR5)	6.7	0.44	6.67-6.84	0.2178
Lower Left Second Premolar (LL5)	6.7	0.54	6.68-6.90	

*p<0.05 statistically significant

Table 1 shows no significant difference was found between the mesio-distal widths of right and left sided teeth.

Table 2: Descriptive statistics for sum of mesio-distal widths of mandibular right & left central and lateral incisors, maxillary and mandibular right & left canines, maxillary and mandibular right & left first and second premolars (P is the result of the independent t test n=50 for each gender)

Tooth group	Sex	Mean (mm)	SD(mm)	95%CI	Range	Mean difference (SE)	P-value
Upper Right Canine-UR3	M	7.7	0.43	7.59-7.84	6.50-8.68	0.30(0.07)	0.0002*
	F	7.4	0.35	7.31-7.51	6.63-8.11		
First Premolar- UR4	M	6.7	0.47	6.59-6.86	5.78-8.12	0.01(0.08)	0.9239
	F	6.7	0.40	6.61-6.83	6.04-7.48		
Second Premolar- UR 5	M	6.26	0.49	6.12-6.40	5.06-7.18	-0.09(0.08)	0.2477
	F	6.36	0.34	6.26-6.45	5.70-7.23		
Upper left Canine-UL3	M	7.7	0.43	7.57-7.82	6.52-8.66	0.28(0.07)	0.0005*
	F	7.4	0.34	7.32-7.51	6.61-8.10		
First Premolar- UL4	M	6.7	0.46	6.59-6.85	5.77-8.11	0.01(0.08)	0.8957
	F	6.7	0.39	6.60-6.82	6.05-7.47		
Second Premolar- UL5	M	6.2	0.49	6.12-6.40	5.07-7.17	-0.09(0.08)	0.2736
	F	6.3	0.34	6.26-6.45	5.72-7.22		
Lower Right Central Incisor-LR1	M	5.3	0.30	5.23-5.40	4.76-6.10	0.10(0.08)	0.1991
	F	5.2	0.48	5.08-5.35	4.60-7.77		
Lateral Incisor- LR2	M	5.8	0.36	5.69-5.89	5.11-6.56	0.08(0.07)	0.2268
	F	5.7	0.37	5.60-5.81	5.16-6.60		
Canine- LR3	M	6.74	0.44	6.62-6.87	5.90-7.62	0.24(0.07)	0.0021*
	F	6.50	0.32	6.40-6.59	5.75-7.16		
First Premolar- LR4	M	6.8	0.50	6.70-6.99	5.88-7.92	0.12(0.09)	0.1534
	F	6.7	0.39	6.60-6.83	5.95-7.53		
Second Premolar- LR5	M	6.7	0.44	6.58-6.83	5.90-8.01	-0.09(0.08)	0.2810
	F	6.8	0.43	6.68-6.92	5.73-7.90		
Lower left Central Incisor-LL1	M	5.3	0.29	5.23-5.40	4.77-6.11	0.12(0.07)	0.0816
	F	5.1	0.41	5.07-5.30	4.62-6.61		
Lateral Incisor- LL2	M	5.8	0.35	5.70-5.90	5.18-6.61	0.09(0.07)	0.1832
	F	5.7	0.36	5.60-5.80	5.12-6.55		
Canine- LL3	M	6.8	0.42	6.64-6.89	6.06-7.62	0.27(0.07)	0.0006*
	F	6.5	0.32	6.40-6.59	5.74-7.15		
First Premolar- LL4	M	6.8	0.49	6.71-6.99	5.87-7.93	0.13(0.08)	0.1279
	F	6.7	0.38	6.61-6.83	5.96-7.54		

*p<0.05 statistically significant

Table 2 shows only significant difference was found between the mesio-distal widths of canines in male and female teeth.

Table 3: Descriptive statistics for sum of mesio-distal widths of mandibular incisors, maxillary and mandibular canines and premolars (P is the result of the independent t test

Tooth group	Sex	Mean (mm)	SD (mm)	95%CI	Range	Mean difference (SE)	P-value
Lower incisors	M	22.2	1.23	21.88-22.58	19.87-24.96	0.17	0.1128
Lower incisors	F	21.8	1.36	21.43-22.20	19.45-25.34	0.19	
Maxillary canines and premolars	M	20.7	1.23	20.36-21.06	17.75-23.75	0.17	0.3156
Maxillary canines and premolars	F	20.5	0.84	20.25-20.73	19.00-22.48	0.11	
Mandibular canines and premolars	M	20.3	1.22	19.96-20.65	17.84-23.03	0.17	0.2165
Mandibular canines and premolars	F	20.0	1.03	19.73-20.32	17.84-22.14	0.14	

*p<0.05 statistically significant

Table 3 shows difference between the mesio-distal widths of male and female teeth but not statistically significant.

Table 4: Regression parameters for prediction of buccal segment widths

Tooth group				Constants		
	Sex	r	r^2	a	b	SEE (mm)
Maxillary arch	M	0.49	0.24	9.64	0.49	0.12
	F	0.56	0.32	12.8	0.35	0.07
	M+F	0.52	0.27	11.4	0.41	0.06
Mandibular arch	M	0.49	0.24	9.40	0.49	0.12
	F	0.57	0.33	10.5	0.43	0.08
	M+F	0.53	0.29	9.91	0.46	0.07

r = The correlation coefficients between the mesio-distal widths of the mandibular incisors and canine to premolars for male, female and a combined group
a and b = The regression constant values
r^2 = The coefficient of determination
SEE = Standard error of the estimate
Table 4 shows the correlation coefficients (r) between the sum of the mesio-distal widths of the lower incisors and the sum of the mesio-distal widths of the canines and premolars were 0.49 for both maxilla and mandible for males. The equivalent figures for the females was 0.56 (maxillary canines and premolars) and 0.57 (mandibular canines and premolars) and for both sexes combined the correlations were 0.52 (maxillary canines and premolars) and 0.53 (mandibular canines and premolars). These values suggest that a reasonable correlation exists between the mesio-distal widths of the lower permanent incisors and the actual mesio-distal widths of the canines and premolars.

1. Equation for Correlation Coefficient (r)

$$r = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\sqrt{\Sigma(x-\bar{x})^2 \Sigma(y-\bar{y})^2}}$$

2. Equation for regression constant values "a" and "b"

$$b = \frac{\Sigma(x-\bar{x})(y-\bar{y})}{\Sigma(x-\bar{x})^2}$$

$$a = \bar{y} - b\,\bar{x}$$

Here,
r = The correlation coefficients
x = values of independent variable
$\bar{x}$ = mean of independent variable
y = values of dependent variable
$\bar{y}$ = mean of dependent variable
Independent variable = Sum of mandibular incisors
Dependent variable = Sum of canines and premolars (for both maxilla & mandible)

Table 5: Comparison of predicted and actual values of Moyers, Tanaka and Johnston methods and present study for male

	Predicted values of ∑CPM		Actual values of ∑CPM		Difference between predicted and actual values		
Prediction methods	Mean	SD	Mean	SD	Mean	SD	P-value
Moyers 50% (1988)	20.8	0.4	20.5	0.4	0.3	0.08	0.0003*
Tanaka and Johnston(1974)	21.9	0.7	20.5	0.4	1.4	0.11	0.001*
Present study	20.4	0.3	20.5	0.4	-0.1	0.07	0.1605

∑CPM= sum of mesio-distal width of canines and premolars *p<0.05 statistically significant

Table 5 shows significant difference was found in Moyers and Tanaka & Johnston prediction method between the predicted mesio-distal widths and actual mesio-distal width of canines & premolars for male.

In male, both the Moyers and Tanaka and the Johnston methods overestimate the actual width of canine and premolars and these differences were statistically significant.

Table 6: Comparison of predicted and actual values of Moyers, Tanaka and Johnston methods and present study for female

Prediction methods	Predicted values of ∑CPM		Actual values of ∑CPM		Difference between predicted and actual values		P-value
	Mean	SD	Mean	SD	Mean	SD	
Moyers 50% (1988)	20.8	0.7	20.2	0.5	0.6	0.12	0.0001*
Tanaka and Johnston(1974)	21.6	0.8	20.2	0.5	1.4	0.13	0.0001*
Present study	20.1	0.3	20.2	0.5	-0.1	0.08	0.2282

∑CPM= sum of mesio-distal width of canines and premolars *p<0.05 statistically significant

Table 6 shows significant difference was found in Moyers and Tanaka & Johnston prediction method between the predicted mesio-distal widths and actual mesio-distal width of canines & premolars for female. In male, both the Moyers and Tanaka and the Johnston methods overestimate the actual width of canine and premolars and these differences were statistically significant.

Table 7: Regression equation derived from various ethnic groups (Mx=Maxilla, Mn=Mandible)

Study	Population group	Sex	Arch	Regression equation
Moyers[4]*(1988)	North American White	M	Mx	y=9.73+0.51x
*Moyers table 50th percentile		M	Mn	y=10.79+0.45x
		F	Mx	y=14.17+0.28x
		F	Mn	y=8.85+0.52x
Tanaka and Johnston[5] (1974)	North American White	M+F	Mx	y=11.0+0.50x
		M+F	Mn	y=10.5+0.50x
Jaroontham and Godfrey[31]	Northeastern Thailand	M+F	Mx	y=11.87+0.47x
		M+F	Mn	y=10.30+0.50x
		M	Mx	y=13.36+0.41x
		M	Mn	y=11.92+0.43x
		F	Mx	y=11.16+0.49x
		F	Mn	y=9.49+0.53x
Al Khadra[18]	Saudi Arab	M+F	Mx	y=7.20+0.63x
		M+F	Mn	y=8.60+0.55x
Zilberman et al.[32]	Israeli	M+F	Mx	y=7.2+0.63x
		M+F	Mn	y=8.6+0.55x
Yuen et al.[19]	Hong Kong Chinese	M	Mx	y=7.97+0.66x
		M	Mn	y=8.82+0.58x
		F	Mx	y=8.30+0.61x
		F	Mn	y=6.66+0.64x
Diagne et al.[28]	Black Senegalese	M+F	Mx	y=9.87+0.53x
		M+F	Mn	y=5.67+0.70x
		M	Mx	y=9.60+0.55x
		M	Mn	y=5.45+0.72x
		F	Mx	y=13.77+0.35x
		F	Mn	y=8.74+0.56x
Alhaija and Qudeimat[36]	Jordanian	M+F	Mx	y=10.55+0.53x
		M+F	Mn	y=9.41+0.53x
Peng et al[38]	Mainland Chinese	M	Mx	y=10.87+0.51x
		M	Mn	y=10.3+0.50x
		F	Mx	y=11.88+0.56x
		F	Mn	y=10.03+0.49x
Alok K Jaiswal[15]	Nepalese	M+F	Mx	y=13.35+0.35x
		M+F	Mn	y=11.60+0.40x
		M	Mx	y=15.52+0.26x
		M	Mn	y=14.44+0.28x
		F	Mx	y=12.16+0.40x
		F	Mn	y=10.12+0.46x
Present Study	Bangladeshi	M+F	Mx	y=11.4+0.41x
		M+F	Mn	y=9.91+0.46x
		M	Mx	y=9.64+0.49x
		M	Mn	y=9.40+0.49x
		F	Mx	y=12.8+0.35x
		F	Mn	y=10.5+0.43x

DISCUSSION

In this study, we have measured tooth size in a sample of 50 Bangladeshi males and 50 females in order to aid the determination of space requirements in the mixed dentition.

The coefficients of determination (r^2) values are indications of predictive accuracy. In the present study, Then Bangladeshi females possessed higher r^2 values (0.32 for maxillary teeth and 0.33 for mandibular teeth) compared to males (0.24 for both arch). Some authors[19,33] obtained higher r^2 values for males whereas others[30] have reported higher r^2 values for females. These differences in r^2 values might be due to differences in sample sizes and ethnic diversity.

The SEE (Standard error of the estimate) denotes error involved in the use of prediction equations. The lower the SEE, the better the prediction equation. For the present study, the SEE ranged from 0.07 to 0.12 (Table 4).

Applying the values of coefficients a and b, listed in Table 4, four equations for the prediction of mesio-distal dimensions of the maxillary and mandibular canines and premolars were derived as follows:

1. for Bangladeshi males:
Maxillary arch: y = 9.64+0.49x
Mandibular arch: y = 9.40+0.49x

2. for Bangladeshi females:
Maxillary arch: y = 12.8+0.35x
Mandibular arch: y = 10.5+0.43x

Where x is the mesio-distal dimension of the four permanent mandibular incisors in millimeters; y is the mesio-distal dimension of the canines and premolars in millimeters.

Using these regression equations, we can predict the mesio-distal width of unerupted permanent canines and premolars for Bangladeshi subjects. Here 'x' is the sum of the widths of the lower permanent incisors and 'y' is the predicted value of the mesio-distal width of the unerupted permanent canines and premolars. Table 7 shows the prediction equations formulated from different populations found in the literature.

For Bangladeshi males, Moyers method[4] at 50% tends to overestimate the actual value of the canines and premolars by 0.3 mm with a standard deviation of 0.08 mm, whereas the Tanaka and Johnston 5 method tends to overestimate the actual value of the canines and premolars by 1.4 mm with a standard deviation of 0.11 mm (Table 5).

For Bangladeshi females, Moyers method at 50% tends to overestimate the actual value of the canines and premolars by 0.6 mm with a standard deviation of 0.12 mm, whereas the Tanaka and Johnston method tends to overestimate the actual value of the canines and premolars by 1.4 mm with a standard deviation of 0.13 mm (Table 6).

The Moyers method uses percentiles to increase the accuracy of their prediction method. They suggested that the 75th percentile is the most accurate level for the prediction of crowding. In the present study, we found that when the Moyers method was applied to our Bangladeshi sample at the 50th percentile it overestimated tooth size; therefore if it was applied at the 75th percentile the prediction error would be even greater. Tanaka and Johnston framed their equations for predicting the sum of the unerupted canine and premolar widths as regression formula without mentioning any percentage level.

Using the new regression equations, the mean difference between the predicted and actual width of the canine and premolars was calculated. The values are -0.1 (SD 0.07) whereas p-value 0.1605 for males, and 0.1 (SD 0.08) whereas p-value 0.2282 for females. These values were not statistically significant (Tables 5 and 6).

Many authors[16,17,23] have reported variations in the mesio-distal widths of permanent teeth in different racial and ethnic groups. Table 7 shows comparisons between the regression equations of the present study with different ethnic groups from other studies. Bangladeshi females have the largest constant 'a' (12.8) in the maxillary arch (Tables 4 and 7).

Therefore, data derived from one ethnic group might not be applicable to another ethnic group for the purpose of the prediction of the size of unerupted permanent (canine and premolars) teeth.[3,18,19] The prediction equations obtained, from the data based on a Bangladeshi population, and would be more accurate and reliable to Bangladeshi subjects despite the ethnic diversity of Bangladesh.

There is a difference between statistical and clinical significance. Proffit[1] suggests that a mean error of <1.5 mm is not clinically significant for a Bolton's analysis. Our results found differences between predicted and actual tooth size of less than 1 mm per quadrant; however if multiplied for all four quadrants then the findings could be clinically

significant. The other limitation is that the prediction correlations only account for a small percentage of the variation. This suggests that differences in tooth size between individuals may limit the accuracy of the prediction correlations and therefore they should only be used as a guide as to future space requirements.

CONCLUSION

In conclusion, it can be suggested that both the Tanaka & Johnston and the Moyers prediction methods lead to inaccuracies when determining the actual widths of the canines and premolars in Bangladeshi subjects. So, the newly developed prediction equations in this present study will help in forming orthodontic treatment planning for Bangladeshi population.

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