Proposed regression equations for prediction of the size of unerupted permanent canines and premolars in Yemeni sample

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ABSTRACT

Objective: The aim was to formulate a prediction regression equation for Yemeni and to compare it with Moyer's method for the prediction of the size of the un-erupted permanent canines and premolars.
Subjects and Methods: Measurements of mesio-distal width of four permanent mandibular incisors, as well as canines and premolars in both arches were obtained from a sample of 400 school children aged 12-14 years old (13.80 ± 0.42 standard deviation) using electronic digital calliper. The data were subjected to statistical and linear regression analysis and then compared with Moyer's prediction tables.
Results: The result showed that the mean mesio-distal tooth widths of the canines and premolars in the maxillary arch were significantly larger in boys than girls ($P < 0.001$), while, in the mandibular arch, only lateral incisors and canines were also significantly larger in boys than in girls ($P < 0.001$). Regression equations for the maxillary arch (boys, $Y = 13.55 + 0.29X$; girls, $Y = 14.04 + 0.25X$) and the mandibular arch (boys, $Y = 9.97 + 0.40X$; girls, $Y = 9.56 + 0.41X$) were formulated and used to develop new probability tables following the Moyer's method. Significant differences ($P < 0.05$) were found between the present study predicted widths and the Moyer's tables in almost all percentile levels, including the recommended 50% and 75% levels.
Conclusions: The Moyer's probability tables significantly overestimate the mesio-distal widths of the un-erupted permanent canine and premolars of Yemeni in almost all percentile levels, including the commonly used 50% and 75% levels. Therefore, it was suggested with caution that the proposed prediction regression equations and tables developed in the present study could be considered as an alternative and more precise method for mixed dentition space analysis in Yemeni.

Key words: Mixed dentition Yemeni, Moyer's prediction, probability tables, predicted tooth size, regression equations

INTRODUCTION

The period of late primary dentition or early mixed dentition is a critical period for the prevention or interception of any developing malocclusion.[1] The treatment of malocclusion in this period is more advantageous, because of the opportunities for occlusal guidance, interception of the malocclusion or removal of the etiological factor.[2] Some prediction methods for estimating the size of un-erupted canine-premolars segments have been established. These methods include direct measurement of the width of permanent canine, first and second premolars from dental radiographs[3] or utilizing tables to predict the size of permanent canine, first and second premolars based on their correlation to the mesio-distal width of the mandibular permanent incisors.[4-6] Out of these predicted methods; Moyer's method, which was considered to be the most widely used method in providing a high degree of accuracy without the need for radiographic or special equipment.[5] Moreover, Moyer's table can be used for both the maxillary and mandibular arch estimation.[6] The mixed dentition analysis developed by Moyer utilized the sum of the mandibular permanent incisors as the independent variable. At

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Access this article online

Quick Response Code:

Website: www.jorthodsci.org

DOI: 10.4103/2278-0203.137689

the 50% level; this analysis tended to be optimistic, but at the 80% level, the number of over-estimations was balanced by the number of under-estimations. Moyer[6] considered this level to be superior to that of other mixed dentition analyses tested.[7] The combination of radiographic measurements and prediction table's methods recommended by Hixon and Oldfather[8] was considered the most accurate, but it was complex and many found it difficult to use.[9,10] However, other methods[3,4,6] were found either to over-estimate by 1-3 mm, or was more likely to under estimate by 0.5 mm.[5,8]

Simple linear regression equation was formulated for mixed dentition space analysis for many population around the world.[11-16] A review of the literature revealed that Moyer's prediction tables of mixed dentition analysis were not an accurate method to estimate the tooth dimension in Senegal;[17] Indonesian Javanese;[18] Belgaum[19] and in other Arab population.[13-16,20,21]

However, the evidence of racial tooth size variability suggested that prediction techniques based on a single racial sample may not be considered universal.[21] Hence, it was the intention of the present study to develop a regression equation for prediction of the size of the un-erupted permanent canine-premolar segment and establish prediction tables for clinical use based on the normative standard of mesio-distal tooth widths of permanent teeth in Yemeni.

SUBJECTS AND METHODS

Population and Sample

After obtaining the informed consent which was reviewed and approved at institutional level, this cross-sectional study was conducted in Sana'a city, the capital of the republic of Yemen. Sana'a city is divided into ten districts. The four districts of Northern, Central, East, and Southern parts were randomly selected. To assure statistically correct representation of the population from which the sample was drawn out, the number of included children in each district was proportional to the population of that district. Therefore, two secondary government schools from the North and South and three secondary government schools from the East and Middle were randomly selected. All children in the selected schools were examined, and those who met the inclusion criteria were included in the study until the required sample was obtained.

The study sample consisted of 400 school children (200 boys and 200 girls) aged 12-14 years old (mean 13.80 ± 0.42 standard deviation), selected from five randomly selected secondary government schools.

Inclusion Criteria

Native Yemen; aged 12-14 years; fully erupted permanent teeth in both arches (with the exception of second and third molars); Class I molar and canine relationship with normal over jet and overbite.

Exclusion Criteria

Children having crowding, rotated or malformed teeth, congenitally missing, extracted teeth, proximal caries, hypoplastic teeth, Class II restoration that affect the mesio-distal width of the teeth and children undergoing orthodontic treatment.

Measurement of Mesio-distal Tooth Widths

Measurements of mesio-distal width of the four mandibular incisors teeth, as well as canines and premolars in both lower and upper arches were done directly on the dental casts as carefully as possible to avoid any damage to the casts. Mesio-distal width was measured between the two anatomical contact points of each tooth using electronic digital caliper (Digimatic Caliper, Mitutoyo, U.K).

The method of measuring the mesio-distal tooth width was performed as described by Hunter and Priest.[22] The caliper beaks were inserted from the buccal (labial) and held occlusally parallel to the long axis of the tooth and also parallel to the vestibular surface of the casts. The beaks were then closed until gentle contact with the contact points of the tooth was made.

The sum of the following groups of teeth (four mandibular incisors; mandibular canines and premolars; the maxillary canines and premolars) were pooled and the mean mesio-distal tooth width was calculated for each sex separately, and for the whole sample.

Measurement Errors

For measurement reliability, inter-examiner error was assessed by randomly selecting the study casts of 30 children. The teeth were measured twice by the same investigator (Al-Kabab) on two different occasions and the average of the two readings was taken as the diameter of the individual tooth. If the first and second measurements differed by more than 0.20 mm, a third measurement was taken, and the two closest values were averaged.[23]

Prediction of Mesio-distal Widths of Canines and Premolars

A simple regression analysis of the dependent variable (the mean sum of the mesio-distal widths of the permanent canines, first and second premolars) was performed with independent variables (mean sum of four mandibular incisors) to devise a possible regression equation for the Yemeni sample and compared it with the predicted values obtained from Moyer's probability tables.

The estimated regression equation for the prediction of tooth size in Yemeni takes the form of: $y = a + b\ (x)$ where:

y = The predicted size of the canines, and first and second premolars in one quadrant in millimetres.

x = The measured width of the four permanent mandibular incisors in millimetres.

(a) and (b) are the estimated regression constant and

regression coefficient, respectively.

RESULTS

A total of 800 sets of dental casts were obtained from 200 boys and 200 girls, aged 12–14 years old with the mean age of 13.80 ± 0.42 for boys and 13.79 ± 0.43 for girls.

Table 1 shows that the mean mesio-distal tooth widths of the permanent canine and premolars in boys were larger than girls in both arches. For the maxillary teeth, only canine and first premolar widths showed statistically significant differences between both sexes ($P < 0.001$). The mean mesio-distal tooth widths of mandibular lateral incisors and canines showed statistically significant differences between both sexes ($P < 0.001$).

Descriptive statistics for the three tooth groups measured (mandibular permanent incisors, mandibular canine-premolar segment, and maxillary canine-premolar segment) were presented in Table 2 for both sexes separately.

The result of the Student's *t*-test for the comparison of the mesio-distal tooth widths between the boys and the girls revealed a high significant difference ($P < 0.001$) in all three tooth groups indicating boys having larger teeth [Table 2].

When the data were analyzed, new regression equations were derived separately for boys and girls in order to predict tooth size of the un-erupted permanent canine and first and second premolars.

The coefficient of determination (r^2) indicators of predictive accuracy of the regression equation for *Y* (the sum of mesio-distal widths of canine and premolars) based on values of *X* (the sum of mesio-distal widths of four mandibular incisors). This coefficient of determination represents the proportion of the total variance of *Y*, which was determined by the *X* value of each regression equation.

The regression characteristics of the obtained prediction equations for Yemeni sample were presented in Table 3. Regression equations for the maxillary arch (boys, $Y = 13.55 + 0.29X$; girls, $Y = 14.04 + 0.25X$) and for the mandibular arch (boys, $Y = 9.97 + 0.40X$; girls, $Y = 9.56 + 0.41X$) were used to develop new probability prediction tables as the one presented by Moyer. The correlation coefficients ranged from 0.28 to 0.47 with higher coefficients value in girls than in boys. Also the (r^2) values ranged from 7% to 22% with the power of the regression model greater in girls.

Table 4 presents the probability values for Yemeni and also demonstrated the comparison between the predicted value of the mesio-distal widths of canines, first and second premolars obtained from the regression equation in the present study and the predicted values derived from Moyer's tables in both arches for boys and girls. The result revealed that predicted values in Moyer's charts at the 75th, 50th and 35th percentile confidence level were overestimated when compared with the present study predicted values when using the proposed new regression equation.

DISCUSSION

Table 1: Comparisons of mesio-distal widths of the selected mandibular and maxillary teeth between boys and girls

Tooth	Mean±SD		*t* value	*P* value	SE	95% CI
	Boys=200	Girls=200				
Maxillary						
Canines	7.19±0.48	7.01±0.47	3.92	0.000**	0.047	0.09-0.27
First premolars	6.44±0.44	6.30±0.47	2.59	0.003**	0.046	0.04-0.22
Second premolar	5.95±0.44	5.84±0.49	2.42	0.016*	0.047	0.02-0.20
Mandible						
Central incisor	4.99±0.34	4.93±0.36	1.67	0.094	0.035	−0.01-0.13
Lateral incisor	5.34±0.38	5.20±0.37	3.50	0.001**	0.038	0.05-0.20
Canines	6.07±0.41	5.89±0.41	4.41	0.000**	0.041	0.10-0.26
First premolars	6.17±0.46	6.10±0.51	1.43	0.154	0.048	−0.02-0.16
Second premolar	6.05±0.46	5.96±0.47	1.94	0.053	0.047	−0.00-0.18

SD – Standard deviation; CI – Confidence interval; SE – Standard error. Signifiant *P<0.05; **P<0.001

Table 2: Descriptive statistics for summations of mesio-distal widths of mandibular incisors, and maxillary and mandibular canine and premolar segments

Sum of teeth	Boys (*n*=200)			Girls (*n*=200)			*t* value	*P* value
	Mean	Range	SD	Mean	Range	SD		
Mandibular incisors	20.68	17.34-24.92	1.92	20.27	16.32-25.24	1.31	3.13	0.002*
Mandibular canine and premolars	18.27	16.87-22.33	1.09	17.95	16.27-22.86	1.23	2.74	0.006*
Maxillary canine and premolars	19.59	12.45-20.91	1.06	19.16	14.84-21.33	1.17	3.79	0.000*

SD – Standard deviation. Signifiant *P<0.001

Prediction of the mesio-distal tooth width of un-erupted permanent canines and premolars during the mixed dentition stage is of clinical importance for determining occlusal guidance, diagnosis, and proper treatment plan.[12]

In the present study, the mandibular incisors have been chosen for establishing a new predicted regression equation. This is because of their early eruption in the early mixed dentition stage and they are easily accessible and measured. Moreover; they were reported in several studies as the best predictors when performing the linear regression equations for the determination of the combined mesio-distal widths of the un-erupted permanent canines and premolars.[6] This finding was confirmed by a previous study carried out by Motokawa[24] who found that, the sum of the four mandibular incisors is one of the best predictors in the linear regression equations in determining the combined mesio-distal widths of the un-erupted permanent canines and premolar. However, other studies reported the opposite. They stated that; the combined widths of the four mandibular permanent incisors were not a good predictor for estimating the mesio-distal diameters of the un-erupted permanent mandibular permanent canines and premolars.[23,25]

Philip *et al*.[12] stated that; the size of the teeth is related to racial and gender-specific. Therefore, mixed dentition space analysis may require revision or validation once every generation (approximately 30 years) because of the changing trends in malocclusion and tooth size.[12]

In the present study, gender discrepancy was observed, the sum of the mesio-distal widths of mandibular incisors, and canines-premolars segments were significantly larger in boys than in girls. This finding was in agreement with other studies conducted in Hong Kong Chinese;[26] Thai;[11] Zagreb,[27] Senegalese[17] population. They reported sexual dimorphism in their studies.

The boys in the present study; show significantly larger mesio-distal widths of canines and premolars in the maxillary arch while the same was observed in the mandibular arch where only lateral incisors and canines were significantly larger. Further; the canines were found to be the most sexually dimorphic teeth in the arch. This could be attributed to the hypothesis that; the greater the canine dimorphism; the greater the sexual dimorphism of adjacent teeth.[9] These results were similar to the findings reported by Hattab *et al*.[28]

Comparisons of mesio-distal tooth widths in the present study and other population exhibited that both Yemeni boys and girls in the present study show smaller combined mesio-distal tooth widths compared to that in black South Africans;[29] black

Table 3: Regression parameters for prediction of mesio-distal widths of canine-premolar segments

Sex	Canine-premolar segment	*r*	Constants		r^2	SEE (mm)
			a	*b*		
Boys	Maxillary	0.35	13.55	0.29	0.12	0.99
	Mandibular	0.47	9.97	0.07	0.07	0.96
Girls	Maxillary	0.28	14.04	0.652	0.22	1.13
	Mandibular	0.44	9.56	0.19	0.19	1.1

r – Correlation coefficients; *a* and *b* – Regression constants; r^2 – Coefficient of determination; SEE – Standard error of estimate

Table 4: Predicted values of the present study and Moyer's study at the 35th, 50th and 75th percentile

Percentile	19.5	20	20.5	21	21.5	22	22.5	23	23.5	24	24.5	25	25.5
Boys													
Maxilla													
75	20.3	20.5	20.8	21.0	21.3	21.5	21.8	22.0	22.3	22.5	22.8	23.0	23.3
50	19.7	19.9	20.2	20.4	20.7	20.9	21.2	21.5	21.7	22.0	22.2	22.5	22.7
35	19.3	19.6	19.9	20.1	20.4	20.6	20.9	21.1	21.4	21.6	21.9	22.1	22.4
Present values	19.2	19.4	19.5	19.6	19.8	19.9	20.1	20.2	20.4	20.5	20.7	20.8	20.9
Mandible													
75	20.4	20.6	20.8	21.0	21.2	21.4	21.6	21.9	22.1	22.3	22.5	22.8	23.0
50	19.5	19.7	20.0	20.2	20.4	20.6	20.9	21.1	21.3	21.5	21.7	22.0	22.2
35	19.0	19.3	19.5	19.7	20.0	20.2	20.4	20.6	20.9	21.1	21.3	21.5	21.7
Present values	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0	20.3
Girls													
Maxilla													
75	20.4	20.5	20.6	20.8	20.9	21.0	21.2	21.3	21.5	21.6	21.8	21.9	22.1
50	19.6	19.8	19.9	20.1	20.2	20.3	20.5	20.6	20.8	20.9	21.0	21.2	21.3
35	19.2	19.4	19.5	19.7	19.8	19.9	20.1	20.2	20.4	20.5	20.6	20.8	20.9
Present values	18.9	19.0	19.2	19.3	19.4	19.5	19.7	19.8	19.9	20.0	20.2	20.3	20.4
Mandible													
75	19.6	19.8	20.1	20.3	20.6	20.8	21.1	21.3	21.6	21.9	22.1	22.4	22.7
50	18.7	19.0	19.2	19.5	19.8	20.0	20.3	20.5	20.8	21.1	21.3	21.6	21.8
35	18.2	18.5	18.8	19.0	19.3	19.6	19.8	20.1	20.3	20.6	20.9	21.1	21.4
Present values	17.6	17.8	18.0	18.2	18.4	18.6	18.8	19.0	19.2	19.4	19.6	19.8	20.0

Americans;[30] Hong Kong Chinese;[26] Thai;[11] Senegalese groups;[17] Jordanian[16] and Indian population.[12,19] This finding may justify why the Moyer's predicted values were overestimated.

In the present study, the girls show a higher coefficient of determination values (r^2) 0.22 in maxillary teeth and 0.19 in mandibular teeth than boys 0.12 in maxillary and 0.07 in mandibular teeth. This result coincides with results of previous studies carried out in Thai and Jordanian population.[11,16] Nevertheless, for Hong Kong Chinese, (r^2) values were higher in boys than girls in both arches.[26] However, the correlation coefficients (r^2) obtained in the present study [Table 3] were lower than those reported in several previous studies.[8,12,23]

When using Moyer's charts for prediction of un-erupted permanent canine and premolars; the result of the present study revealed that the values in Moyer's charts at the 75th, 50th, and 35th percentile confidence level were overestimated in both arches for the boys and girls. This result agreed with reports of previous studies.[13,17,29] They found that the predicted tooth sizes in Moyer's chart were greater than the predicted tooth size[13] and disagreed with former studies who concluded that Moyer's prediction tables underestimated tooth size in Black South African and Indian children.[12,26] However, Moyer's prediction tables of mixed dentition analysis show varied results for both sexes of school children in Belgaum.[19] Furthermore, the result of the present study showed that the Moyer's probability tables were found to overestimate significantly the predicted value of the mesio-distal widths of permanent canine and premolars of Yemeni in almost all percentile levels, including the commonly used 75% and 50% levels. However; in a study conducted among Saudi males and females; revealed that the predicted tooth widths was closer to the 50% confidence level in Moyer's chart.[21] However, This implies that Moyer's method of prediction may have population variations. Therefore, it is suggested with caution that the new presented prediction tables developed from the formulated regression equation in the present study could be considered as a more precise mixed dentition space analysis in Yemeni.

CONCLUSIONS

- Mesio-distal tooth widths of Yemeni were smaller compared to other population with significant sex differences.
- A proposed prediction regression equation was formulated based upon the sum of the mandibular incisors widths for prediction of the size of the un-erupted permanent mandibular and maxillary canines and premolars for Yemeni.
- The Moyer's probability tables significantly overestimate the mesio-distal widths of the un-erupted permanent canine and premolars of Yemeni in almost all percentile levels, including the commonly used 50% and 75% levels.

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How to cite this article: Al-Kabab FA, Ghoname NA, Banabilh SM. Proposed regression equations for prediction of the size of unerupted permanent canines and premolars in Yemeni sample. J Orthodont Sci 2014;3:68-73.

Source of Support: Nil, **Conflict of Interest:** None declared.