

# Applicability of Moyer's Method of Mixed Dentition Analysis in a Tanzanian Population

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## ABSTRACT

**Introduction:** Space analysis is the process of evaluating whether the available space in a dental arch is enough to accommodate all the erupting permanent teeth. In mixed dentition, where some permanent teeth have not yet erupted, tooth size prediction is required to compute the analysis. For accurate prediction and analysis, customized data is needed since tooth size varies between populations. Therefore, the present study aimed to assess the applicability of Moyer's method of mixed dentition analysis, and to determine the tooth groups with the best correlation in predicting the sum of unerupted canine and premolars in the Tanzanian population.

**Materials & Methods:** The study involved 204 study casts of patients aged between 12 and 30 years who sought orthodontic treatment at the Muhimbili University Dental Clinic. The mesiodistal width of permanent teeth was measured using a digital vernier caliper. Comparison between actual and predicted measurements was performed using a paired sample t-test. Correlation analysis was conducted to assess the relationship between different tooth groups, and linear regression was used to derive a new prediction formula.

**Results:** There was no statistically significant difference observed between the right and left sides of the jaws, however, males had greater tooth width compared to females. Moyer's method significantly underestimated the width of canine and premolars at the 50th and 75th percentiles and overestimated the same measurements at the 90th percentile. The combined width of lower incisors and the first lower permanent molars displayed the highest correlation in predicting the size of unerupted canines and premolars. Therefore, they were used to formulate population-specific prediction formulas.

**Conclusion:** Moyer's method of mixed dentition analysis was not a reliable method for predicting the size of unerupted canines and premolars in the Tanzanian population. The use of the newly generated prediction formulas is recommended.

**KEYWORDS:** Space analysis, Tooth size correlation, Tooth size prediction.

## INTRODUCTION

Space discrepancies are the most common malocclusion during the mixed dentition stage.<sup>1</sup> Their interventions require an accurate estimation of space needed and space available for aligning the available and expected permanent teeth. Nevertheless, accurate estimation may be impossible if the sizes of unerupted teeth are unknown and cannot be predicted precisely. Several methods of predicting the size of

unerupted canines and premolars have been developed worldwide.<sup>2</sup> Moyer's method is one of them, it is among the earliest methods of mixed dentition analysis, which has been widely used in tooth size predictions.<sup>2,3</sup> The method predicts the combined mesiodistal width of unerupted canines and premolars using a probability table developed from a study involving the North American Caucasian population.<sup>4,5</sup>

Since the discovery of the method, several studies have been conducted worldwide to assess its applicability in groups of different ethnicities. The majority of these studies have claimed the method to either overestimate or underestimate teeth size measurements in their populations.<sup>4,6-8</sup> Considering this inconsistency, it was reasonable to question the use of this method in the Tanzanian population as it had never been validated before. Therefore, the current study aimed to assess the applicability of Moyer's method and to determine the tooth group with the highest correlation in predicting the sum of unerupted permanent canines and premolars in this population.

## MATERIALS AND METHOD

The study involved study casts of patients who attended Orthodontic clinic at Muhimbili University, a teaching and referral dental center from February 2020 to August 2022. The expected sample size was 291, which was estimated using a formula for finite population as described by Yamane 1967 and given by  $n = N / (1 + N (e)^2)$ . Where  $N$  = sample size,  $n$  = finite population size 1070,  $e$  = the acceptable sampling error (0.05),  $p$  = degree of variability (0.5) and 95% confidence level. Retrieval of study casts taken during the study period revealed a total of 1070 study casts that were obtained from patients with no previous history of orthodontic treatment and aged between 14 to 30 years. The study casts were screened and only 204 models met the inclusion criteria for the current study. The criteria were; study casts with (i) a fully erupted permanent dentition up to the second molars, (ii) good quality (iii) well labeled and (iv) with no any obvious tooth size anomalies. Moreover, casts with caries, severe crowding, missing and supernumerary teeth were excluded from the study. The ethical clearance to conduct the study was obtained from the research ethical committee of Muhimbili University.

A preliminary study involving twenty study models was carried out before conducting the main study in which, the accuracy of the digital Vernier caliper (Guanglu, Guilin PR. China, 0.01 mm accuracy) used in the study was calibrated using a manual caliper. All measurements were carried out by one calibrated examiner and only 5 casts were examined daily to avoid errors due to eye fatigue. Fifteen casts were re-examined to assess intra-examiner reliability and good consistency was found between the two sets of measurements (intra-class correlation coefficient 0.98).

Data collection involved measurement of the mesiodistal width of all permanent teeth excluding second and third

molars. The measurements were carried out according to the method described earlier by Hunter and Priest.<sup>9,10</sup> The sum of four permanent mandibular incisors was used to estimate the combined size of permanent canines and premolars using Moyer's probability chart at the 50<sup>th</sup>, 75<sup>th</sup>, and 90<sup>th</sup> percentile.

Analysis was done using SPSS software, version 25.0. The relationship between the predicted and actual measurements was assessed using a paired sample t-test. Correlation coefficients for different tooth groups were calculated to determine the best predictor of the combined mesiodistal widths of the canine and premolar for the studied population. Simple linear regression analysis was used to formulate prediction equations for the current study.

## RESULTS

A total of 204 sets of study models were obtained from 113 females and 91 males with a mean age of  $17 \pm 4$  years. Independent sample t-test found a statistically significant difference in tooth size measurements between sexes. However, the difference between right and left side measurements was not statistically significant. Thus, the average measurements were calculated and later used for analysis in the present study.

With regard to correlation analysis, the highest coefficient was observed in the combination of four lower incisors and lower first molars. It was followed by the combination of four lower incisors and upper first molars. The most commonly used teeth (sum of the lower incisor) showed a modest correlation compared to other tooth groups. The coefficients of correlation were relatively higher in the lower jaw and in male group (Table 1).

When Moyer's predictions were compared with the actual measurements, a weak correlation was observed. The predicted measurements at 50<sup>th</sup> and 75<sup>th</sup> percentiles were significantly less than the actual measurements, while those at 90<sup>th</sup> percentile were greater than the actual measurements ( $p < 0.001$ ) (Table 2). The predictive accuracies of the combined width of premolars and canines based on the combined width of lower incisors and first permanent molars were presented in Table 3, where they ranged from 0.44 in females' lower teeth to 0.52 in males' lower teeth.

Regression equations for estimation of the mesiodistal width of unerupted canines and premolars were developed for the current study using the combined widths of the lower four incisors and the first permanent molar as predictors. The new equations were presented

in terms of  $y = a + bx$ , where;  $y$  is the dependent variable (predicted mesio-distal widths of canines and premolars), " $x$ " is (independent variable) the combined mesio-distal width of four lower incisors, and the first

lower permanent molars, " $a$ " is the Y Intercept and " $b$ " is the slope of the regression line. Linear regression equations were statistically significant for both sexes ( $p < 0.05$ ) (Table 3).

**Table 1- Correlation coefficients for different teeth groups in predicting the combined width of canines and premolars according to arch and sex**

Teeth groups	Upper jaw		Lower jaw	
	Male (n = 91)	Female (n = 113)	Male (n = 91)	Female (n = 113)
Mandibular central incisors	0.63	0.61	0.65	0.62
Mandibular lateral incisors	0.61	0.64	0.62	0.62
Mandibular four incisors	0.63	0.61	0.65	0.62
Mandibular incisors and first upper molars	0.71	0.64	0.72	0.66
Mandibular incisors and first lower molars	0.69	0.66	0.73	0.70
Mandibular central incisors and first lower molars	0.65	0.61	0.69	0.68
Mandibular central incisors and upper first molars	0.66	0.58	0.67	0.61
Mandibular lateral incisors and first upper molars	0.69	0.63	0.70	0.63
Mandibular lateral incisors and first lower molars	0.65	0.65	0.69	0.70

**Table 2- Comparison between the actual width of canines and premolars and Moyer's predictions at the 90<sup>th</sup>, 75<sup>th</sup> and 50<sup>th</sup> percentile.**

Percentile	Sex	Jaw	Actual measurement		Predicted measurements		MD	P- value
			Mean	SD	Mean	SD		
90 <sup>th</sup>	Male	Upper jaw	22.93	1.19	23.13	0.72	-0.27	.018*
		Lower jaw	22.81	1.20	23.31	0.65	-0.5	<.001*
	Female	Upper jaw	22.41	1.09	22.42	0.41	-0.02	0.843
		Lower jaw	22.29	0.99	22.68	0.69	-0.39	<.001*
75 <sup>th</sup>	Male	Upper jaw	22.93	1.19	22.27	0.72	0.66	<.001*
		Lower jaw	22.81	1.20	22.13	0.63	0.68	<.001*
	Female	Upper jaw	22.41	1.09	21.42	0.39	0.99	<.001*
		Jaw	22.29	0.99	21.40	0.59	0.89	<.001*
								<.001*
50 <sup>th</sup>	Male	Upper jaw	22.93	1.19	21.78	0.77	1.15	<.001*
		Lower jaw	22.81	1.20	21.56	0.83	1.25	<.001*
	Female	Upper jaw	22.41	1.09	20.70	0.38	1.71	<.001*
		Lower jaw	22.29	0.99	20.73	0.71	1.56	<.001*

MD = Mean difference (Actual measurement – predicted measurement), SD = standard deviation,

\* Statistically significant

**Table 3- Regression parameters for the prediction of the combined mesio-distal width of canines and premolars from the sum of mesio-distal widths of lower incisors and lower first molar**

		Coefficient correlation	Regression coefficients		SEE	(r <sup>2</sup> )	P - value
			a	b			
Male	Upper jaw	0.69	5.63	0.37	0.90	0.48	0.000
	Lower jaw	0.73	3.58	0.41	0.92	0.52	0.000
Female	Upper jaw	0.66	6.82	0.40	0.89	0.44	0.000
	Lower jaw	0.70	6.72	0.03	0.81	0.49	0.000

r<sup>2</sup> = Coefficient of determination, SEE = Standard error of estimate, a = Y-intercept and b = slope of the regression line.

**Table 4- New regression equation for predicting the size of unerupted canines and premolars for the present study.**

	Upper jaw	Lower jaw
Males	$y = 5.63 + 0.37x$	$y = 3.58 + 0.41x$
Females	$y = 6.82 + 0.40x$	$y = 6.72 + 0.03x$

Y = Combined mesiodistal width of permanent canines and premolars. X = combined mesiodistal width of the permanent lower incisors

## DISCUSSION

There is no agreement in the literature regarding which percentile level of Moyer's chart should be used in tooth size predictions.<sup>11</sup> Moyer's initial study recommended the use of the 75<sup>th</sup> percentile in tooth size predictions.<sup>12</sup> However, this percentile has been claimed to be inaccurate in most of the studies, with some authors recommending the use of higher percentile while others suggest lower percentiles.<sup>11,13-15</sup> Regarding this, the current study assessed Moyer's predictions at three different percentiles, 90<sup>th</sup>, 75<sup>th</sup>, and 50<sup>th</sup> percentiles. The chosen percentiles were hypothesized to be close to the present actual measurements. Nevertheless, the present findings did not differ from the previous findings, as the method was found to be inaccurate at all percentile levels. Inaccuracy of this method has also been reported in studies from other African countries such as those from Nigeria,<sup>13</sup> Egypt,<sup>16</sup> and Libya,<sup>17</sup> as well as other parts of the world.<sup>4,6,7,11</sup> Considering this, Moyer's method is probably accurate only in North American Caucasians and a few other populations. Hence, the method should be used with caution in other populations.

Moyer's prediction chart does not provide the predicted values of canines and premolars when the combined width of lower incisors is greater than 25.5mm. This is one of the major limitations of this method especially

in ethnicities with larger teeth than the Caucasian population. For instance, in the present study, 11% of the sample had a combined width of lower incisors of more than 25.5mm, thus the method could not be used in this sample.

The most preferred teeth for tooth size prediction during mixed dentition stage are the sum of lower permanent incisors.<sup>2,23</sup> In the current study, the correlation coefficient of lower incisors in determining the size of canines and premolars ranged from 0.60 to 0.65. This coefficient was substantial enough for these teeth to be used as teeth size predictors.<sup>24</sup> Nevertheless, for better precision, the current study used tooth groups with the highest correlation in estimating the size of unerupted teeth. The highest correlation coefficient was recorded when the sum of the first lower permanent molars was added to that of the lower incisors. Therefore, these teeth were used to generate new formulas for predicting the size of unerupted canines and premolars for the Tanzanian population. These teeth were chosen because they are the first permanent teeth to erupt regardless of the difference in sex and ethnicity between populations.<sup>18-21</sup> Additionally, the mesiodistal width of these teeth has also shown a positive correlation with the combined width of the canines and premolars in the previous studies.<sup>22</sup> Although upper permanent incisors also erupt early, they were not used in the present study

because of their greater tooth size variability between individuals. The use of lower incisors and first lower permanent molars in teeth size predictions has also been recommended in other populations.<sup>25-27</sup>

The correlation coefficient of the present predictor teeth ranged from 0.66 in females' maxillary teeth to 0.73 in males' mandibular teeth. These coefficients were similar to those reported in Kenya, ranging from 0.67 to 0.725.<sup>26</sup> However, it was relatively less than those reported from Malaysia<sup>25</sup> and Brazil.<sup>27</sup> Since the present formulas were obtained using tooth with highest correlation, they will certainly provide a more precise predictions than the previous recommended in this population.<sup>28</sup>

Nevertheless, the newly generated formula should be used with caution since the present study population may not be completely reflecting the anatomical diversity in teeth size and shape existing between Tanzanian tribes. Therefore, a countrywide validation of the newly generated formula is recommended.

## CONCLUSION

The Moyer method was not accurate in predicting the size of unerupted teeth in Tanzanian population. The combined width of lower permanent incisors and lower first molars was found to be the best predictor of the size of unerupted canines and premolars in Tanzanian population.

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