

Keywords

mixed dentition space analysis, Moyer's probability chart, validity of Moyer's analysis, regression equation, prediction of width of unerupted permanent teeth

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Validity of Moyer's Analysis and a New Proposed Regression Equation in a Sample of Kurdish population

ABSTRACT

Objectives: This research carried out to assess the validity of Moyer's probability in Kurdish people; in addition to formulate a new regression equation for Kurdish population. **Methods:** This research is a cross-sectional retrospective study. Totally 150 pairs of orthodontic study casts randomly selected from two governmental specialized clinic in Erbil city. The age ranged 13-30 years. The total mesiodistal width of incisors, canines and premolars were measured by the use of a digital vernier caliper. The total width of four lower incisors used to formulate a new regression equation to determine the predicted width of un erupted upper and lower canines and premolars. **Results:** new regression equations suggested for Kurdish population for both upper and lower arches, a strong correlation determined between the actual and the predicted width of upper and lower canines and premolars. There was a significant difference between study result and the 75th percentile of Moyer's probability chart.

Conclusion: The 75th percentile of Moyer's chart is not valid for Kurdish population. New regression equation can be used to predict the total mesiodistal width of un erupted canine and premolar. Clinical relevance: predicting width of unerupted teeth provides valuable information for planning treatment in mixed dentition period

INTRODUCTION

A correct diagnosis is the first step towards a successful orthodontic treatment, and mixed dentition analysis is considered a fundamental step to make a good diagnosis. (1) In several cases, the dental malocclusions begin in mixed dentition period. As the lower incisors erupt early, prediction of mesiodistal width of unerupted mandibular and maxillary canines and premolars by measuring mesiodistal width of the erupted four permanent mandibular incisors is beneficial; hence it provides an idea about the space required for permanent canines and premolars and accordingly establish a treatment plan if there is possibility of malocclusion. (2) Space analysis is the process of calculating the amount of space required in each arch. (3) It is important to calculate the amount of space available for teeth in the dental arch because treatment varies, depending on whether the space is adequate, insufficient, or excessive. (4)

Four basic principles involved during mixed dentition space analysis in prediction of the width of unerupted premolars and canines. They are prediction tables and equation, measurement of unerupted teeth on intraoral periapical radiographs, regression equation methods and a combination of prediction tables and radiographs. (5) One of the most widely used replacement tooth analysis methods is Moyer's prediction table analysis. (6) Moyer's prediction tables with 75th percentile level is universally used method for prediction of the mesiodistal crown width of unerupted teeth. (7) Moyer's prediction was based on North American Caucasian children & Northern European descent. It is not applicable to all racial groups because it has been observed that tooth dimension varies in different ethnicities, races and genders. (2,5,6,8-17) A narrative review of orthodontic models further confirmed this trend, noting that Moyer's tables, rooted in Northern European data, overestimate space needs in Asian and Middle Eastern groups

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leading to potential overtreatment. (18) Furthermore; in another systematic review, they found that using of Moyer's probability chart in mixed dentition space analysis should be done with care because in most of the articles involved in their study, the 75th percentile value was not accurate in predicting the width of unerupted canine and premolar. Therefore, they suggest that the probability tables be adapted according to each population. (19)

Moyer's mixed dentition analysis still widely used because of its simplicity. To my knowledge, there is no study on the validity of Moyer's probability table for Kurdish population. The objective of this study is to assess the validity of Moyer's mixed dentition space analysis and to determine a new regression equation based on our measurements

METHODS

This research is a cross-sectional retrospective study, a total of 150 pairs of orthodontic study casts of patients who had been treated by fixed appliance were randomly selected from two different governmental specialized orthodontic clinics, postgraduate orthodontic clinic of Khanzad specialized polyclinic and post graduate clinic of the College of Dentistry, Hawler Medical University, Kurdistan Region, Iraq. These casts were available in the mentioned clinics between March 2025 to March 2026. The age of the patients were 13-30 years. This age selected to be sure that the patient had all permanent teeth included in the measurement. The study was approved by the ethics committee of the College of Dentistry, Hawler Medical University, Kurdistan Region, Iraq. The inclusion criteria include:

1. Native Kurdish patients.
 2. Fully erupted permanent teeth except 3rd molar.
 3. Teeth that were included in the measurement should not have proximal caries, restoration or crown.
 4. Measurements were done on pre-orthodontic treatment study models.
 5. The patients should not have congenitally missing teeth, malformations, impaction, fracture or wearing.
- All the casts with poor quality, interproximal caries, proximal restoration or wearing excluded from the study.

An electronic digital caliper with 0.01 mm accuracy has been used in this study. The beaks of the caliper hold parallel to the occlusal surface of the teeth, then the mesiodistal width of lower incisors, upper and lower canines and premolars (both in right and left side) measured between the proximal contact points. All the measurement were done by one investigator.

The mesiodistal width of four lower permanent incisors measured on the orthodontic cast and then summed. The mesiodistal width of upper and lower canines and premolars measured in both right and left side, then the average obtained. The total width of lower permanent incisors used as independent variable to determine the predicted width of summed upper and lower canine and premolars. Then a new repression equation obtained for this study.

The predicted and actual mesiodistal width of upper and lower canines and premolars were correlated.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS, version 26). Normality of the data was assessed with the Shapiro-Wilk test. The strength of the relationship between the two numerical variables (actual and predicted values) was evaluated using Pearson's correlation coefficient. To determine the level of agreement between the actual and predicted values, the intraclass correlation coefficient was used. A one-sample t-test was applied to compare the mean predicted sum of the canine and premolar teeth to Moyer's 75th percentile values. Cohen's d was calculated to measure effect size. Multiple regression analysis was conducted to predict the combined sum of the upper and lower canines and premolars. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The sum of the width of the lower canines and premolars can be predicted by knowing the value of the sum of the width of the lower incisors using the following formula that was created by the multiple regression analysis: Predicted sum of width of lower canines and premolars = $8.630 + (0.531 * \text{sum of the width of the lower incisors})$ (Table 1).

Table 1. Regression analysis between the sum of the lower canines and premolars as a dependent variable, and the sum of the width of the lower incisors as an independent variable.

	Unstandardized Coefficients		Standardized Coefficients	t	p-value	95.0% Confidence Interval for B	
	B	SE	Beta			Lower Bound	Upper Bound
(Constant)	8.630	1.169		7.384	< 0.001	6.321	10.940
Sum of lower incisors	0.531	0.052	0.642	10.176	< 0.001	0.428	0.634
Regression equation: Predicted sum of the width of lower canines and premolars = $8.630 + (0.531 * \text{sum of the width of the lower incisors})$.							

The sum of the width of upper canines and premolars can be predicted by knowing the values of the sum of the width of the lower incisors using the following formula that was created by the multiple regression analysis:

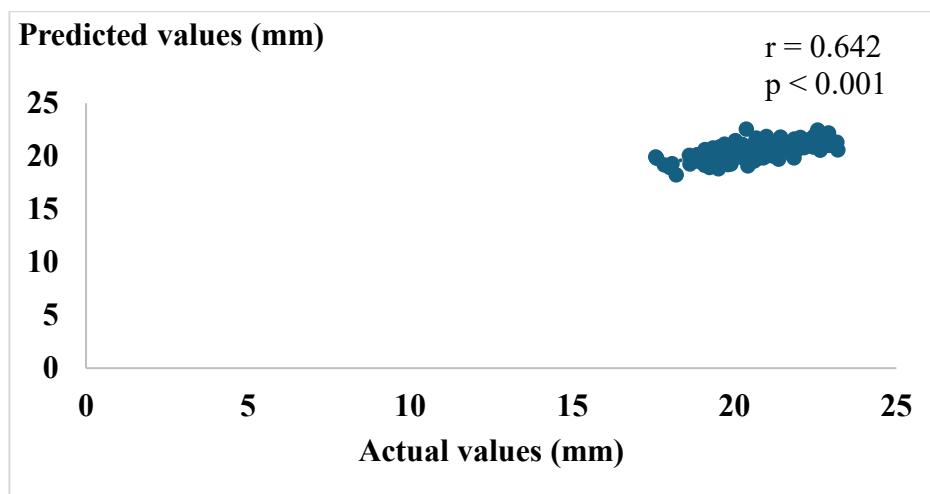
Predicted sum of the width of upper canines and premolars = $8.358 + (0.562 * \text{sum of the width of the lower incisors})$ (Table 2).

Table 2. Regression analysis between the sum of the upper canines and premolars as a dependent variable, and the sum of the lower incisors as an independent variable.

	Unstandardized Coefficients		Standardized Coefficients	t	p-value	95.0% Confidence Interval for B	
	B	SE	Beta			Lower Bound	Upper Bound
(Constant)	8.358	1.135		7.362	$p < 0.001$	6.114	10.601
Sum of lower incisors	0.562	0.051	0.674	11.088	$p < 0.001$	0.462	0.662
Regression equation: Predicted sum of the width of upper canines and premolars = $8.358 + (0.562 * \text{sum of the width of the lower incisors})$.							

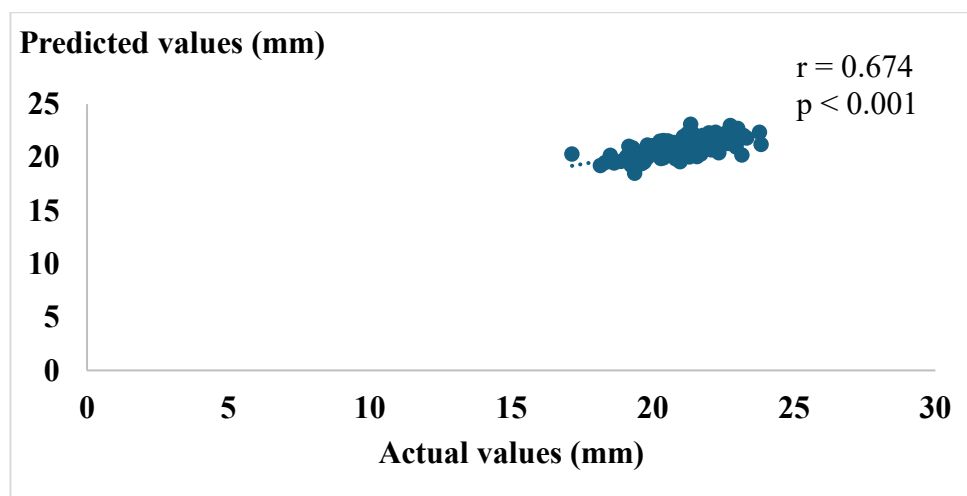
A significant positive correlation was found between the predicted and actual values of the sum of the lower canines and premolars ($r = 0.642$; $p < 0.001$).

The intraclass correlation between the predicted and the actual values was 0.738 ($p < 0.001$) (Figure 1).

**Figure 1. Correlation between the actual and predicted values of the sum of the lower canines and premolars.**

A significant positive correlation was found between the predicted and actual values of the sum of the upper canines and premolars ($r = 0.674$; $p < 0.001$).

The intraclass correlation between the predicted and the actual values was 0.770 ($p < 0.001$) (Figure 2).

**Figure 2. Correlation between the actual and predicted values of the sum of the upper canines and premolars.**

All the means of the predicted sum of the upper canines and premolars were significantly ($p < 0.001$) less than the

75th percentile of Moyer's values. Very high values of Cohen's d were detected for all the comparisons (Table 3).

Table 3. Prediction of the width of the Upper canines and premolars by each Moyer table value in the study subjects.

Sum of Lower incisors (mm)	Mean predicted sum of Upper canine and premolar (mm)	Moyer's values (Upper)				p-value*	Effect size**
		35%	50%	65%	75%		
19.5	19.48	19.6	20	20.4	20.6	< 0.001	-17.4
20	19.69	19.9	20.3	20.6	20.9	< 0.001	-9.9
20.5	19.99	20.2	20.6	20.9	21.2	< 0.001	-13.8
21	20.32	20.5	20.8	21.2	21.5	< 0.001	-16.3
21.5	20.53	20.8	21.1	21.5	21.8	< 0.001	-15.9
22	20.88	21	21.4	21.8	22	< 0.001	-12.1
22.5	21.14	21.3	21.7	22	22.3	< 0.001	-17.2
23	21.41	21.6	21.9	22.3	22.6	< 0.001	-14.2
23.5	21.66	21.9	22.2	22.6	22.9	< 0.001	-14.8
24	21.97	22.1	22.5	22.8	23.2	< 0.001	-14.6
24.5	22.28	22.4	22.8	23.1	23.5	< 0.001	-18.4

*Comparing the mean predicted sum of upper canine and premolar with the 75th percentile (by one-sample t-test).

**Estimated by Cohen's d

All the means of the predicted sum of the lower canines and premolars were significantly ($p < 0.001$) less than the

75th percentile of Moyer's values. Very high values of Cohen's d were detected for all the comparisons (Table 4).

Table 4. Prediction of the width of the Lower canines and premolars by each Moyer table value in the study subjects

Sum of Lower incisors (mm)	Mean predicted sum of Lower canine and premolar (mm)	Moyer's values (Lower)				p-value*	Effect size**
		35%	50%	65%	75%		
19.5	19.14	19	19.4	19.8	20.1	< 0.001	-15.8
20	19.34	19.3	19.7	20.1	20.4	< 0.001	-9.2
20.5	19.62	19.6	20	20.4	20.7	< 0.001	-13.0
21	19.93	19.9	20.3	20.7	21	< 0.001	-15.6
21.5	20.13	20.2	20.6	21	21.3	< 0.001	-15.5
22	20.46	20.5	20.9	21.3	21.6	< 0.001	-13.0
22.5	20.70	20.8	21.2	21.6	21.9	< 0.001	-14.4
23	20.96	21.1	21.5	21.9	22.2	< 0.001	-15.6
23.5	21.20	21.4	21.8	22.2	22.5	< 0.001	-16.4
24	21.49	21.7	22.1	22.5	22.8	< 0.001	-16.4
24.5	21.79	22	22.4	22.8	23.1	< 0.001	-21.0

*Comparing the mean predicted sum of upper canine and premolar with the 75th percentile (by one-sample t-test).

**Estimated by Cohen's d

DISCUSSION

Determining the amount of space available in the dental arch for unerupted permanent teeth during mixed dentition by performing space analysis is essential for reaching a correct diagnosis and planning a suitable treatment in mixed dentition period therefore accurate prediction of the width of unerupted canines and premolars is helpful. The Moyer's predication table which is used for mixed dentition space analysis is derived from Caucasian populations which might not be accurate for other ethnic groups. (15)

This study is carried out to determine if Moyer's probability chart is valid for Kurds. In addition to generate a new regression equation suitable for our population. While the 75th percentile is the commonly utilized clinical standard in Moyer's space analysis, this study found that this level overestimates the width of unerupted

canines and premolars in Kurdish population. This result is in accordance with the findings of several other studies performed on various populations. (2,4,6,12,15,17, 22) This difference might be due to difference in ethnic background between Moyer's research population and other research populations. This means that Kurdish population has smaller teeth when compared to Northern American and Caucasian ethnicities. In reverse, some authors found statistically significant underestimation of Moyer's analysis compared to their data. (8,13)

The 35th percentile of Moyer's chart is more applicable to be used for our population than 75th percentile. This result aligns with that done for the following populations: Saudi 15,20, south Indian 9, Himachal 12 and Egyptian. (21) Overall, while Moyer's analysis remains a cornerstone of mixed dentition diagnostics for its simplicity and non-invasive nature, its validity is population-dependent, often requiring modifications like

lower percentiles or alternative predictors (e.g., incorporating first molars) to enhance accuracy. (22)

Regarding the correlation between actual mesiodistal width of upper and lower canines and premolars and the predicted one calculated from regression equation, there is a strong correlation between them. This indicated that the suggested new regression equation for our sample can be used as an alternative to Moyer's prediction table for prediction of the width of un erupted canine and premolar during mixed dentition although it is preferred to perform the same study on larger number of participants to be able to generalize the equation.

CONCLUSION

1. The 75th percentile of Moyer's probability table is not valid for mixed dentition space analysis in Kurdish population, 35th percentile can be used with limitations.
2. The sum of lower incisors can be used for prediction of the total width of un erupted upper and lower canines and premolars.
3. New regression equation suggested for prediction of width of un erupted canines and premolars.
4. Performing the study on larger sample size is still required to get a probability table for Kurdish population which can be used clinically.

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