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ORIGINAL RESEARCH

New Regression Equations for Mixed Dentition Space Analysis in an Iranian Population

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ABSTRACT

Aims: Prediction of the mesiodistal crown width of unerupted canines and premolars is an important aspect of mixed dentition analysis. The accuracy of Tanaka-Johnston equations, the most commonly method, is questionable when it is applied to different ethnic groups. In this study, we aimed to develop a new regression equation for this prediction in an Iranian population.

Materials and methods: The dental casts of 120 Iranian subjects with complete permanent dentition were selected. Mesiodistal crown widths of teeth were measured with digital caliper. In the first part of the study, the correlation and linear regression equations between four mandibular incisors and the canine-premolars segments of both arches were developed (modified Tanaka-Johnston equation). In the second part, as a new method, correlation and linear regression equations were developed between the sum of mandibular central incisors-maxillary first molars and the canine-premolars segments.

Results: It was found that the correlation coefficients between the sum of mandibular central incisors-maxillary first molars and the maxillary and mandibular canine-premolars segments were higher ($r = 0.66, 0.68$ respectively) than the one between the four mandibular incisors and the canine-premolars segments ($r = 0.58. 0.64$).

Conclusion: New linear regression equations were derived. In this study, the sum of mandibular central incisors and maxillary first molars was better predictor for unerupted canines and premolars. This novel approach allows the prediction of width of unerupted canines and premolars to take place at earlier age.

Clinical significance: Using the new method, orthodontists could take advantage of mixed dentition analysis at earlier age. Moreover, to test the derived equations on a larger sample size and in other ethnicities is highly recommended.

Keywords: Tooth size, Prediction, Mixed dentition analysis.

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INTRODUCTION

Prediction of the mesiodistal width of unerupted permanent canines and premolars to determine whether available space is enough which is conventionally named 'mixed dentition analysis' is an important aspect of orthodontic diagnosis. Based on this prediction, treatment plan can be introduced ranging from conservative and simple procedures such as periodic observation only, guidance of eruption, space maintenance, space regaining, and expansion to more complicated mechanisms such as serial extraction.[1,2]

Historically, initial attempts to estimate tooth size were made by GV Black, but the data was clinically unreliable due to the great individual variability in tooth size.[3] Carey et al reported the existence of a significant linear correlation between the mesiodistal width of the permanent lower incisors and the mesiodistal width of the permanent canines and premolars. Since then many other attempts were made to estimate the unerupted permanent tooth sizes.[4-6]

Currently, mixed dentition analysis methodologies are divided into three major groups: (1) direct measurements of unerupted tooth size on periapical or 45° cephalometric radiographs as Nance and Depaula methods, (2) calculations from prediction equations and tables as Moyers and Tanaka-Johnston techniques, (3) a combination of linear regression equations and measurements on radiographs as Hixon-Oldfather and Staley-Kerber methods.[6-11] Among different mixed dentition analysis methods, the regression equations based on the erupted permanent mandibular incisors, particularly the Tanaka-Johnston method, are the most widely used.[5,9] This method is based on the fact that teeth tend to have a close relationship in their proportional sizes in the same individual, but the accuracy of Tanaka-Johnston method is fairly good when applied to children of Northern European descent, from which the data were originally obtained.[9,10] However; it has been reported that mesiodistal tooth sizes vary considerably between different populations and ethnicities because of the genetic and environmental factors.[12-17] Furthermore, several studies have described that sexual dimorphism exists in tooth sizes.[18,19] Therefore, the accuracy of the published norms may be questionable when they are applied into other ethnicities. Consequently, specific predictive data may be necessary for each ethnic groups.[12] Moreover; most of current predictive equation methods are based on a good correlation between size of mandibular permanent incisors and size of permanent canines and premolars.[12,20] Nourallah et al on a Syrian population survey, reported that using sum of width of mandibular central incisors and maxillary first molars as predictors had improved prediction results compared to using sum of widths of four mandibular incisors.[2] As first molars and mandibular central incisors are first erupting permanent teeth, thus if their crown widths could be applied for prediction of the size of remaining unerupted teeth, therefore we could take advantage of mixed dentition analysis at earlier age.

The purpose of this study was to determine accurate equations for predicting the sizes of unerupted canines and premolars in an Iranian population by using 1—sum of the four mandibular incisors, 2—sum of the first maxillary molars and the mandibular central incisors as predictors.

MATERIALS AND METHODS

One hundred and twenty dental casts (60 males and 60 females) of 14 to 25 years old orthodontic patients were selected from records of orthodontic offices in Yazd/Iran. All casts fulfilled following selection criteria as stated by many authors: fully eruption of permanent first molar to first molar in both jaws, no interproximal caries or restorations, no pervious orthodontic treatment, no alteration in teeth size, shape or number, no attrition, normal to mild crowding or spacing.[8,17,21-25] The sample included different types of occlusion. All dental models were constructed from high-quality orthodontic dental stone.

Greatest mesiodistal crown widths of permanent teeth from first molar to first molar in upper and lower arches were measured. The measurements were carried out according to the method described by Moorrees et al using a digital sliding caliper (Mitutoyo manufacturing Co. Ltd, Tokyo, Japan) with an accuracy of 0.01 mm.[17] Therefore, the maximum width of the tooth between the interproximal contact points was measured parallel to the occlusal surface and perpendicular to the tooth long axis. To determine the error of the method, all measurements were repeated by the same investigator five days later and the student's t-test revealed no statistical difference. All statistical analysis was carried out by using the SPSS software package (SPSS version 15.0).

Linear regression was used to drive equations for the prediction of the sum of the widths of the canine, first and second premolars in either jaw. The regression equation was expressed as $Y = a + bX$. The constants a and b were calculated for both sexes combined and for males and females separately. In addition, the standard errors of the estimates (SEE), the coefficients of correlation(r) and the coefficients of determination (r^2) were calculated. r^2 values represents the predictive accuracy of the regression equation for Y based on values of X. Otherwise r^2 values indicate the power of the regression models. The new equations were developed to optimize the Tanaka-Johnston method for Iranian children.

Moreover, new regression equations to prediction sum of the mesiodistal widths of canine-premolars based on sum of mesiodistal widths of permanent mandibular central incisors and maxillary first molars was developed. We selected these reference teeth because of their early eruption. Coefficients of correlation(r), coefficients of determination (r^2) and standard errors were also determined.

Table 1: Descriptive statistics of the mesiodistal widths of the four mandibular incisors, the maxillary and mandibular canine-premolars segments and the mandibular central incisors-maxillary first molars

Tooth group	*Sex*	*Mean (mm)*	*SD*	*95% confidence interval*	*D%*	*p-value*
Mandibular incisors	Male	23.40	1.71	22.96-23.84		
	Female	22.99	1.29	22.66-23.33	1.74	0.145
	Combined	23.20	1.52	22.92-23.47		
Maxillary canine and premolars	Male	21.85	1.25	21.53-22.18		
	Female	21.47	1.07	21.19-21.75	1.77	0.077
	Combined	21.66	1.18	21.45-21.87		
Mandibular canine and premolars	Male	21.45	1.29	21.11-21.78		
	Female	20.86	1.06	20.58-21.13	2.83	0.007*
	Combined	21.15	1.22	20.93-21.37		
Mandibular central incisors and maxillary first molars	Male	31.87	1.92	31.37-32.36		
	Female	31.66	1.51	31.27-32.05	0.63	0.517
	Combined	31.76	1.73	31.45-32.08		

SD: Standard deviation; D%: The difference (in percent) between two sexes; *: Significant at $p < 0.05$

RESULTS

Table 1 shows the descriptive statistics for the sum of widths of the mandibular four incisors, the canine-premolars segments, and mandibular central incisors-maxillary first molars for both sexes combined and for males and females separately. The values were generally larger in males than females in both arches and this difference was statistically significant in mandibular canine-premolars segment ($p = 0.007$).

Correlation coefficients and equations of prediction were derived from the sum of the widths of mandibular four incisors and canine-premolars segments. This modified Tanaka-Johnston equation is adjusted for this study subjects. Therefore, following linear regression equation was determined:

$Y = a + b X$

Y represented the estimate of the sum of canine and premolars widths in millimeters on either the right or left side. X indicated the sum of the four mandibular incisors widths in millimeters, the constant a is the Y intercept and the constant b is the slope of the regression. Table 2 shows correlation coefficients (r), determination coefficients (r^2), constants a and b and the standard error of estimate (SEE) for both sexes combined and also for males and females separately. The correlation coefficients ranged from 0.52 to 0.67. Highest r^2 value was 0.44 in females' mandibular arch and lowest one was 0.27 in males' maxillary arch.

As next part of statistics, the new linear regression equations were derived from the sum of widths of mandibular central incisors-maxillary first molars and sum of widths of canine-premolars segments. Therefore, new regression equations in the form of $Y = a' + b'X'$, where X' equals the sum of the widths of mandibular central incisors-maxillary first molars were formulated in male and female separately and for both sexes combined. The regression parameters (a', b', r, r^2, SEE) are shown in Table 3. The correlation coefficients between the sum of mandibular central incisors-maxillary first molars widths and sum of the canine-premolars widths ranged from 0.64 to 0.70. Highest r^2 value was 0.49 in males' mandibular arch and lowest one was 0.41 in females' maxillary arch.

After the comparison of two above determined approaches it was shown that results (r^2 and SEE) were better

Table 2: Regression parameters for prediction of the sum of the widths of canine and two premolars in one quadrant from the sum of the widths of four mandibular incisors

Sex	*Tooth group*	*Correlation coefficient (r)*	*Determination coefficient (r^2)*	*SEE (mm)*	*p-value*	*Constants*	
						a	*b*
Male	Maxillary canine and premolars	0.52	0.27	1.079	0.0001	12.91	0.38
	Mandibular canine and premolars	0.62	0.38	1.027	0.0002	10.51	0.47
Female	Maxillary canine and premolars	0.65	0.42	0.825	0.0001	9.09	0.54
	Mandibular canine and premolars	0.67	0.44	0.799	0.0003	8.22	0.55
Combined	Maxillary canine and premolars	0.58	0.34	0.965	0.0001	11.27	0.45
	Mandibular canine and premolars	0.64	0.42	0.935	0.0003	9.22	0.52

SEE: Standard error of estimation

Table 3: Regression parameters for prediction of the sum of the widths of canine and two premolars in one quadrant from the sum of the widths of mandibular central incisors and maxillary first molars

Sex	*Tooth group*	*Correlation coefficient (r)*	*Determination coefficient (r^2)*	*SEE (mm)*	*p-value*	*Constants*	
						a	*b*
Male	Maxillary canine and premolars	0.68	0.46	0.927	0.0003	7.74	0.44
	Mandibular canine and premolars	0.70	0.49	0.936	0.0001	6.52	0.47
Female	Maxillary canine and premolars	0.64	0.41	0.830	0.0002	7.05	0.46
	Mandibular canine and premolars	0.66	0.43	0.807	0.0001	6.19	0.46
Combined	Maxillary canine and premolars	0.66	0.44	0.885	0.0002	7.28	0.45
	Mandibular canine and premolars	0.68	0.46	0.901	0.0003	6.06	0.48

SEE: Standard error of estimation

in the method that predicts canine-premolars widths based on the sum of mandibular central incisors and maxillary first molars in males and sexes combined groups.

DISCUSSION

The most currently used methods for mixed dentition analysis were developed on Northwestern European origins, but tooth dimensions among various ethnic groups are different.[6,10,13,19,23,26] Our study was performed to establish new regression equations to predict mesiodistal tooth widths of unerupted canines and premolars in an Iranian population.

According to the results the r values for prediction of canine-premolars segments by fours mandibular incisors widths as predictors are: maxillary r = 0.58 and mandibular r = 0.64 which are near to those of Tanaka-Johnston's study (r = 0.62, 0.64).[10] The moderately high degree of linear correlation between sum of mandibular incisors and maxillary/mandibular canine-premolars makes it possible to predict unerupted teeth size by measuring mandibular four incisors widths. We used measured values to generate formulas that could be used clinically for the size prediction of canine-premolars in Iranian population. The derived formulas are:

Maxillary: $Y = 11.27 + 0.45X$

Mandibular: $Y = 9.22 + 0.52X$ (X = four mandibular incisors widths).

Those formulas are different from Tanaka-Johnston's one. The discrepancy may be due to the differences in the ethnicity of cases which is investigated by these studies.[2,10,14,19] Some other studies opted a multiple linear regression equations instead of simple ones.[26-29] Although multiple ones provide better accuracy, they are complex and difficult to memorize. A good prediction method must be precise, simple and practical.

As a second part of the study, we used sum of mandibular central incisors-maxillary first molars for prediction of canine-premolars segment size. The r values for those data are Maxillary r = 0.66 and mandibular r = 0.68. The new regression equations are:

Maxillary: $Y = 7.28 + 0.45X'$

Mandibular: $Y= 6.06 + 0.48X'$ (X' = sum of permanent mandibular central incisors and maxillary first molars).

The comparison of r values in the first and second part of study shows that the correlations between canine-premolars segment and sum of mandibular central incisors-maxillary first molars (r = 0.66, 0.68) are better than correlations between canine-premolars segment and four mandibular incisors (r = 0.58, 0.64). Moreover, it was found that r values are better than original Tanaka-Johnston study (r = 0.62, 0.64),[10] therefore, it may be better that these new teeth (mandibular central incisors and maxillary first molars) to be used for prediction of width of unerupted canines and premolars. Some studies found that using only the mandibular incisors is not a good prediction approach and our results are in consistent with them.[2,26,28-30] Nourallah et al reported that using sum of mandibular central incisors-maxillary first molars for prediction of canine-premolars segment has a high predictive value which is supported by the current study.[2] An important point is that the prediction based on teeth mentioned above which erupt earlier than the teeth used by Tanaka-Johnston, will allow prediction at earlier ages. Paredes et al have suggested the sum of permanent maxillary central incisors-mandibular first molars as best predictors.[30] In this study, we did not use mandibular first molar because it's crown distal area usually covered by gingiva, so measuring it's actual mesiodistal dimension is difficult and not practically accurate.

According to Table 1 in all teeth groups, values are larger in males than females in both arches. This sexual dimorphism has been reported in other studies, but least difference in tooth size between two sexes was in values related to sum of mandibular central incisors-maxillary first molars ($p = 0.517$).[8,19,26,28,31,32] Hence, if one formula would be used for both sexes together, using those teeth as predictors are more near to real values of males and females separately. However; further studies with the larger and representative samples are required to confirm these findings.

CONCLUSION

Modifications made on Tanaka-Johnston's equations allowed the prediction of the size of unerupted canines and premolars with higher accuracy in Iranian population.

Using sum of mandibular central incisors-maxillary first molars widths as predictors of unerupted canines and premolars allows the prediction at earlier age and with more accuracy.

The new regression equations developed for tooth size prediction in Iranian children are as follows:

Maxilla: $Y = 7.28 + 0.45X'$

Mandible: $Y = 6.06 + 0.48X'$

(Y = Sum of widths of canine and premolars of each quadrant, X' = Sum of widths of mandibular central incisors and maxillary first molars).

CLINICAL SIGNIFICANCES

Using the new prediction method, orthodontists could take advantage of mixed dentition analysis at earlier age. Moreover, to test the derived equations on a larger sample size and in other ethnicities is highly recommended.

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