

Reliability of permanent mandibular first molars and incisors widths as predictor for the width of permanent mandibular and maxillary canines and premolars

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Abstract

Aim: Preventive measures are necessary to prevent a potential irregularity from progressing into a more severe malocclusion. The determination of the tooth size–arch length discrepancy in mixed dentition requires an accurate prediction of the mesiodistal widths of the unerupted permanent teeth. **Materials and Methods:** For the study, 200 subjects in the age group of 16–25 years were selected from various colleges of M. M. University. The mesiodistal width of permanent mandibular incisors, first molars, canines and premolars of both arches were measured on the subject cast using an electronic digital caliper. Statistical analysis showed a significant difference between mesiodistal tooth widths of males and females. Linear regression equation was determined to predict the sum of mandibular and maxillary permanent canines and premolars using mandibular first molars plus the four mandibular incisors as predictors. **Results:** There was no significant difference between the actual and predicted width of sum of permanent canines and premolars using regression equations. The predicted widths of both arches using Tanaka and Johnston equations showed significant differences. Determined regression equations for males were accurate in male samples and determined regression equation for females were accurate in female samples for both arches.

Keywords: Preventive orthodontics, regression equation, space analysis

Introduction

Space analysis during mixed dentition is an important aspect in orthodontic diagnosis and treatment planning.^[1] It implies preventive measures, which are necessary to prevent a potential irregularity from progressing into a more severe malocclusion. The determination of the tooth size–arch length discrepancy in mixed dentition requires an accurate prediction of the mesiodistal widths of the unerupted permanent teeth. These analyses should be easy and quick, have minimum error, should not require any special equipment, and should be specific for each arch.^[2] Three approaches have been used to estimate the mesiodistal crown

width of unerupted canines and premolars: (1) measurements from erupted teeth, (2) measurements from radiographs, and (3) a combination of measurements from erupted teeth and from radiographs of unerupted teeth.^[3,4]

Among different mixed dentition analysis methods, the Hixon and Oldfather^[5] approach includes measuring unerupted teeth on radiographs, which are dependent on the quality of X-ray films, the radiographic technique used, and the teeth may be rotated in their crypts so that a true measurement of mesiodistal width cannot be determined from intraoral or extraoral films. Hence, this approach is complex and difficult to use.^[6] The Tanaka and Johnston^[7] prediction equations and tables are based on white North American children, but their use in other populations is questionable due to variations in tooth sizes in different racial groups. Various researches based on Tanaka and Johnston^[7] prediction tables usually overestimated the predicted width of sum of canines and premolars in both arches.^[8,9]

Regression equations based on erupted permanent teeth in mixed dentition period are very simple and have good accuracy. Linear regression was the first type of regression analysis to be studied rigorously and to be used extensively in practical applications. This is because models, which depend linearly on their unknown parameters, are easier to fit than models, which are non-linearly related to their parameters and because the statistical properties of the resulting estimators are easier to determine. The aim of this study was (1) to determine a linear regression equation to predict the sum of mesiodistal width of canines and premolars of both arches by using permanent mandibular incisors and

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permanent mandibular first molars as predictors in M. M. University, Mullana and (2) to assess the differences with Tanaka and Johnston prediction tables.

Materials and Methods

The present study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics, M. M. College of Dental Sciences and Research, Mullana (Ambala, Haryana). Two hundred subjects in the age group of 16–25 years were selected from various colleges of M. M. University, Mullana (Ambala, Haryana), after taking proper consent from the subject. The subject selected had full set of erupted permanent dentition up to first molars in both jaws; no history of previous orthodontic treatment; no clinically visible dental caries, interproximal restorations, distortion, and fractures; no dental anomalies; and no occlusal or proximal attrition. In the present study, impressions of maxillary and mandibular arches of subjects were made with irreversible hydrocolloid impression material using dentulous perforated rim lock impression trays. Type III gypsum product was used to pour impression of the subject for fabrication of the subject cast. The study was carried out by measuring the maxillary and mandibular mesiodistal width on the subject cast, and finally the calculations of SMI (sum of molars and incisors) and SCPM (sum of canines and premolars). [Figure 1]

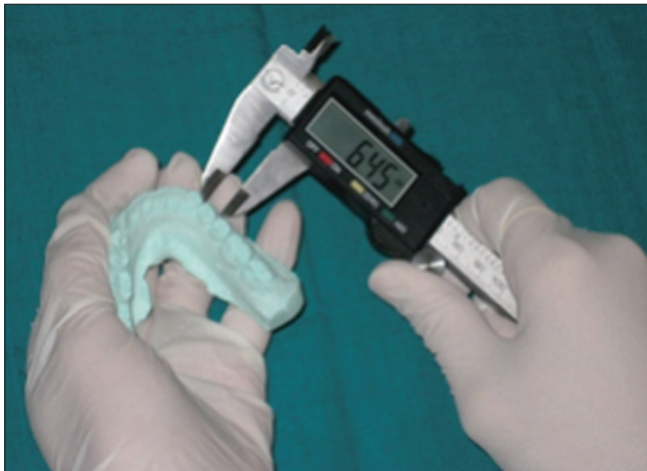


Figure 1: Prevalence of early childhood caries in the children included in the study in relation to age

Results

Correlation between widths of canines and premolars, and the widths of different teeth were calculated. The average widths of left and right canines and premolar cast widths were used as dependent variable. The sum of mandibular first molars plus the four mandibular incisors produced highest correlation (maxillary arch = 0.740; mandibular arch = 0.811). Mean values and standard deviation for the sum of mandibular incisors and first molars (SMI), sum of mandibular canines and premolars (SCPM mandible), and the sum of maxillary canines and premolars (SCPM maxilla) for males and females were obtained. Paired “t” test was applied for each group and statistical significance was calculated [Table 1]. The results showed a significant statistical difference between mesiodistal tooth widths of males and females. Tooth widths were larger in males than in females.

A linear regression equation was determined to predict the sum of mandibular and maxillary permanent canines and premolars with the mandibular first molars plus the four mandibular incisors as predictors. The equation thus determined was calculated as; $y = a + bx$ where “y” is the dependent variable, i.e. sum of mandibular and maxillary permanent canines and premolars, “x” is the independent variable, i.e. sum of mandibular first molars plus the four mandibular incisors, “a” is the y intercept, and “b” is the slope of the regression. The calculated values of constants “a” and “b” are:

	Maxillary	Mandibular
Total sample (M+F)	12.439+0.683X	9.614+0.725X
Male	17.947+0.572X	12.863+0.657X
Female	12.972+0.664X	07.487+0.773X

Based on these new equations, determined regression equation for both sexes was used in total sample, determined regression equation for females was used in female samples, and determined regression equation for males was used in male samples. Mean standard deviation and statistical significance of the predicted values was calculated separately. [Table 2] There was no statistically significant difference between the actual sum of canines and premolars and predicted width by regression equations.

Tanaka and Johnston^[7] prediction method is used for prediction of widths of canines and premolars in both the

Table 1: Mean, standard deviation, and statistical significance of the sum of mesiodistal widths of maxillary and mandibular teeth for both sexes

	N	Male		Female		Difference (Male - Female)		Significance
		Mean	SD	Mean	SD	Mean	SD	
SMI	100	47.4051	2.82372	43.6132	3.08595	3.79490	4.00545	0.000
SCPM (mandible)	100	43.9992	2.44781	41.2052	2.78106	2.79400	3.91728	0.000
SCPM (maxilla)	100	45.0716	2.51861	41.9303	2.55791	3.14130	3.85591	0.000

SMI: sum of molars and incisors; SCPM: sum of canines and premolars

arches. The results were formulated and compared with actual values of sum of canines and premolars in both the arches. Paired “t” test showed significant statistical difference between the actual value of sum of canines and premolars and predicted values by Tanaka and Johnston^[7] prediction equations for males, females, and both sexes. [Table 3] The differences between the predicted widths of both arches with Tanaka and Johnston^[6] equations and actual widths of canines and premolars were highly significant. Tanaka and Johnston^[7] equations overestimated the actual sizes of canines and premolars in both arches.

Discussion

Predicting the size of unerupted teeth during the mixed dentition period is a critical factor in managing the developing occlusion of a growing child. The ability to predict the sizes of unerupted posterior teeth in mixed dentition is of prime importance for a good treatment plan.^[10] Of all

the different mixed dentition analysis methods reported in the literature,^[8-10] the regression equations based on measurements from already erupted permanent teeth in early mixed dentition are the most broadly used.

The mandibular permanent incisor teeth have been found to be the most reliable indices for the size of the remaining permanent teeth. Ballard and Wylie^[11] developed a prediction method having moderately positive correlation coefficient ($r=0.64$), using the sum of the mesiodistal widths of the four mandibular incisors with the combined widths of the mandibular canines and premolars on each side of the arch. Many investigators compiled prediction charts for combined mesiodistal widths of maxillary and mandibular permanent canines and premolar teeth when combined widths of the lower permanent incisor teeth are known.^[5] Tanaka and Johnston^[7] tested the method developed by Ballard and Wylie^[12] with a similar correlation coefficient ($r=0.65$). Correlations between the mandibular permanent incisors

Table 2: Mean and standard deviation of actual and predicted widths of permanent mandibular and maxillary canines and premolars using regression equations, IN mm

Permanent mandibular canines and premolars								
	N	Actual values (SCPM)		Predicted values (SCPM)		Difference (Predicted - Actual)		Significance
		Mean	SD	Mean	SD	Mean	SD	
Male	100	43.9992	2.4478	44.0101	1.85519	-0.01092	1.59767	0.946
Female	100	41.2052	2.78106	41.2000	2.38544	0.0052	1.5423	0.971
Male + Female	200	42.6022	2.96479	42.6093	2.54520	0.00702	1.52175	0.947
Permanent maxillary canines and premolars								
	N	Actual values (SCPM)		Predicted values (SCPM)		Difference (Predicted - Actual)		Significance
		Mean	SD	Mean	SD	Mean	SD	
Male	100	45.0716	2.51861	45.0644	1.61517	0.00717	1.93215	0.970
Female	100	41.9303	2.55791	41.9303	2.55791	0.00086	1.53111	0.996
Male + Female	200	43.5010	2.98163	43.5229	2.39779	0.02182	1.77476	0.982

Table 3: Mean and standard deviation of actual and predicted widths of permanent mandibular and maxillary canines and premolars using Tanaka and Johnston equations, in mm

Permanent mandibular canines and premolars								
	N	Actual values (SCPM)		Predicted values (SCPM)		Difference (predicted - actual)		Significance
		Mean	SD	Mean	SD	Mean	SD	
Male	100	43.9992	2.44781	45.4494	1.31681	1.45020	1.89357	0.000
Female	100	41.2052	2.78106	43.2690	2.44257	2.21905	2.38324	0.000
Male + Female	200	42.6022	2.96479	44.3592	2.24170	1.75700	2.30215	0.000
Permanent maxillary canines and premolars								
	N	Actual values (SCPM)		Predicted values (SCPM)		Difference (Predicted – actual)		Significance
		Mean	SD	Mean	SD	Mean	SD	
Male	100	45.0716	2.51861	45.0716	2.51861	1.37820	1.92492	0.000
Female	100	41.9303	2.55791	44.1494	2.21272	2.06380	2.62251	0.000
Male + Female	200	43.5010	2.98163	44.3592	2.24170	1.79863	2.20151	0.000

Table 4: Comparison of correlation (r) and determination (r²) coefficient in various studies for males and females

	Male		Female		Male + female	
	r	r ²	r	r ²	r	r ²
Present study	0.758	0.574	0.736	0.554	0.858	0.737
Melgaco <i>et al.</i> ^[12]	0.795	0.632	0.774	0.599	0.810	0.656
Tanaka and Johnston ^[7]					0.648	
Ballard and Wylie ^[11]					0.640	
Bernabe and Flores-Mir ^[10]	0.710		0.720		0.720	0.604

and the permanent canines and premolars have been found to be relatively low. Eduardo Bernabe *et al.*,^[10] prepared multiple linear regression equations using combination of the sums of permanent upper and lower central incisors and upper first molars as the best predictors in the study and had better correlation coefficients. Melgaco *et al.*,^[12] determined linear regression equations based on the sum of mesiodistal width of four mandibular permanent incisors and first permanent molars. The proposed method showed high values of correlation and determination coefficients ($r=0.81$ and $r^2=0.656$).

In our study, the mesiodistal width of maxillary and mandibular canines and premolars were correlated with different teeth of both arches. Pearson correlation was applied and its significance at a 0.01 level was found. A strong correlation between the widths of the mandibular and maxillary permanent canines and premolars with those of the mandibular first molars plus the four mandibular incisors was found. Hence, linear regression equation based on combined mesiodistal width of mandibular incisors and mandibular molars was undertaken to predict the mesiodistal widths of mandibular and maxillary canines and premolars. Correlation and determination coefficients were determined for males and females in the study and compared. The results showed that the correlation and determination coefficient for males and females in our study was better than the results from various studies.^[8-10] [Table 4] As expected, on the basis of other studies, no differences for the sum of canines and premolars between either arch sides were found. In this study, we have found a statistical difference between male and female tooth widths. [Table 1] Males had larger teeth than females. Therefore the data were analyzed separately for males and females.

The intra-examiner calibration procedure consisted of two investigators measuring 10 pairs of models two times, separated by 12 h. The error was kept zero after every reading. The investigators analyzed up to 10 models each day to reduce eye fatigue. Each tooth was measured twice in each arch; if the difference was less than 0.2 mm then the first reading was registered. If second measurement differed more than 0.2 mm from the first reading, then the tooth was remeasured.^[12]

Simple linear regression equation was determined to predict values of sum of maxillary and mandibular canines and

premolars based on sum of mandibular first molars and mandibular incisors. The predicted width of canines and premolars was tabulated using the determined regression for both sexes in total sample, determined regression for males in male samples, and determined regression for females in female samples. Mean, standard deviation, and statistical differences in the actual and predicted values determined by regression equations was tabulated. Paired “t” test between the actual and predicted values of sum of maxillary and mandibular canines and premolars using determined regressions showed no significant difference [Table 2].

The error involved in the use of the prediction equations is expressed as the standard error of estimate. Lower the standard error of estimate, better is the prediction equation. The estimates derived from the prediction equations in our study (maxillary arch was 0.16953 and mandibular arch was 0.17996.) are very accurate for widths of canines and premolars on both sides. Paired “t” test showed no significant difference in the actual and predicted sums of maxillary and mandibular canines and premolar widths.

In Tanaka and Johnston^[7] prediction method, the sum of mesiodistal widths of the mandibular incisors was correlated with the sum of mesiodistal width of the mandibular and maxillary canines and premolars. These prediction equations and tables are based on white North American children, but their use in other populations is questionable due to variations in tooth sizes in different racial groups. The results of various researches based on Tanaka and Johnston^[7] prediction tables do not always confirm with the prediction equations According to Kaplan *et al.*,^[13] Tanaka and Johnston^[7] prediction equations overpredicted the values in American-born Northwestern European ancestry population. Sharon Lee-Chan *et al.*,^[9] determined the accuracy of Tanaka and Johnston^[7] prediction equations in Asia-Pacific-American subjects. In mandibular arch, it underestimated the actual size of the canines and premolars when the mesiodistal width of canines and premolars was small. When the mesiodistal width of canines and premolars was large, it overestimated the actual size of canines and premolars. In the maxillary arch, when the mesiodistal width of canines and premolars was small, it overestimated the actual size of the canines and premolars. When the mesiodistal width of canines and premolars was large, it underestimated the actual size of

canines and premolars. Different results are obtained due to differences in ethnic origins of the samples, as Al-Khadra^[8] has found different results when applying the Tanaka and Johnston^[6] method to the Saudi Arab population. Tanaka and Johnston^[7] prediction equations were applied to the samples in our study. The result was tabulated and compared with the actual mesiodistal widths of maxillary and mandibular canines and premolars. Paired “t” test showed significant difference between actual and predicted widths of canines and premolars with the Tanaka and Johnston^[7] equations in both the arches. The Tanaka and Johnston^[7] predicted equation overestimated the width of canines and premolars in both the arches [Table 3].

According to our study, there was a high degree of linear correlation that exists between the sum of the mandibular incisors - mandibular first molars and the mandibular/maxillary canines and premolar segments that makes it possible to measure the tooth width of permanent mandibular incisors and to predict the size of teeth that are yet to erupt.

Conclusion

The purpose of the study was to develop a simple linear regression equations, based on the measurements of 100 males and females for predicting the sum of the mesiodistal widths of unerupted canines and premolar segments in both maxillary and mandibular dental arches. This prediction equation was developed from untreated orthodontic patients studying in different colleges in M. M. University, Mullana, Ambala. Measurements of teeth were taken with a digital caliper. Statistical analysis was conducted to compare the accuracy of the determined linear regression equations and Tanaka-Johnston^[7] prediction equations.

- The sum of the mandibular first permanent molars and permanent incisors was found most accurate in predicting the mesiodistal widths of the mandibular and maxillary permanent canines and premolars.
- Males had statistically significant larger teeth than females.
- Determined regression equation for both sexes was used in total samples, determined regression equation for females was used in female samples, and determined regression equation in males was used for male samples. There was no statistically significant difference between the actual sum of canines and premolars and predicted width by regression equations.
- Correlation coefficient for the sum of the actual mesiodistal widths of the canines and premolars, with their predicted values obtained by determined regression equations and Tanaka-Johnston prediction equations,

was determined. The predicted value by determined regression equations was more accurate than Tanaka and Johnston.^[7]

- Tanaka and Johnston^[7] prediction equations overestimated the widths of canines and premolars in both arches. Hence it is not accurate when applied in our population.
- According to our study, the determined regression equation for males was accurate in male samples and determined regression equation for females was accurate in female samples for both arches. The calculated values are;

	Maxillary	Mandibular
Male	17.947+0.572X	12.863+0.657X
Female	12.972+0.664X	07.487+0.773X

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