

A new proposed regression equation for mixed dentition analysis using the sum of permanent mandibular four incisors and first molar as a predictor of width of unerupted canine and premolars in a sample of North Indian population

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ABSTRACT

Objective: The objective of this study was to establish a new regression equation for North Indian and to compare and correlate the predicted width of unerupted canine and premolars obtained from the proposed regression equation of the present study in the North Indian population sample, Moyer's prediction table and also from Melgaco regression equation with the actual width; in order to check the applicability of various methods of mixed dentition analysis for the North Indian population.

Materials and Methods: The sample consisted of 200 dental casts obtained from the North Indian patients and students which consists of 100 males and 100 females with the average age of 20.12 ± 4.70 years for males and 19.54 ± 3.16 years for females. Mesiodistal tooth widths of mandibular arch from permanent right first molar to left first molar were measured with an electronic digital caliper. Student *t*-test was used for comparison and Pearson's correlation coefficient was used to correlate the actual sum and the predicted width of the permanent mandibular canines and premolars obtained from various methods.

Results: The difference between the actual and predicted width was statistically insignificant using the regression equation obtained for the North Indian sample population (correlation $r = 0.78$) in contrast to the significant difference with predicted width obtained from Melgaco equation ($r = 0.61$) and Moyer's prediction table ($r = 0.42$).

Conclusions: A new proposed regression equation for the North Indian population was established. Amongst the three regression equations devised, the proposed regression equation formulated in the present study; gave the most accurate results confirming racial variation in tooth size. This method is considered as an easy and practical way to predict the size of unerupted canines and premolars.

Key words: Mixed dentition analysis, prediction, regression equation, unerupted canine and premolars

INTRODUCTION AND REVIEW OF LITERATURE

Space analysis in the mixed dentition is an important aspect of orthodontic diagnosis and treatment planning. Considering this, the reliable estimation of the size of unerupted canines and premolars (SCPM) during the mixed dentition is essential for early perception and consequent

interception of potential malocclusion in order to ensure proper growth and facial development.^[1,2] Mixed dentition analysis (MDA) helps in determining whether the treatment plan will include serial extractions, guidance of eruption, space maintenance, space regaining, or just periodic observation of the patient.^[3]

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The concept of dental space analysis to predict the width of unerupted permanent canines and premolars can be categorized into four basic methods i.e., measurements of unerupted tooth on periapical radiographs or 45° cephalometric radiographs,^[4,5] calculations from prediction equations and tables,^[6-8] combination of radiographic measurements and prediction tables^[9-11] and regression equation method.^[6] The radiographic method had a drawback in terms of magnification errors, whereas prediction equation and table tend to overestimate or underestimate the size of unerupted canine and premolars. The regression equation is given by the formula $Y = a + bX$ that establishes a mathematical relation between variables thereby making it relatively an accurate method.

Several linear regression equations have been proposed and published for populations of different ethnic origins with MDA varying among different racial and population groups.^[12,13] Further, sexual dimorphism and racial variation has been confirmed in several studies as the tooth size is greater in males than females.^[12,14-16]

To formulate a regression equation, different combinations of erupted teeth have been used previously to predict the width of unerupted canine and premolars.^[12,14-17] Amongst these; is the combination of the sum of permanent mandibular four incisors and first molars of both sides (sum of incisors and molars [SIM]). This combination gave the highest correlation with the actual width. Hence, it was decided to use the above mentioned combination in North Indian population sample which was also used in the past studies.^[16,18-20] However, before applying this method, it was planned firstly to apply the commonly used Moyer's prediction table for our population.

Until date, no data had been published to predict the width of unerupted permanent canine and premolars for North Indian population; hence, the aims of the present study were to establish a regression equations separately for North Indian males and females subjects and to compare and correlate the predicted values obtained from the Moyer's prediction table, from the regression equation established in the present study and from the regression equation formulated for the Brazilian population by Melgaço,^[16] to the actual width of canine and premolars. This is, in order to check the applicability of the various methods of dental space analysis for North Indian population.

MATERIALS AND METHODS

Sample

The sample of the present study was comprised of dental casts of 200 subjects (100 males, 100 females) chosen from the patients visiting the out-patient dental clinic of the dental college; students of other institutes in the same university in addition to students from various states of North India region.

Criteria of Selection

1. All subjects were natives of North Indian region (at least two generations of the subjects selected belonged to various

states of North India i.e. Uttar Pradesh, Uttarakhand, Delhi, Punjab, Haryana, Rajasthan, Bihar),

2. Having Angle's class I molar and canine relationship,
3. Free from caries and interproximal restorations and
4. Having fully erupted mandibular incisors, canines, premolars and first permanent molar.

Impression and Data Recording

The standard protocol for recording impression was followed and dental casts of high quality, free from distortion, were obtained with dental stone (Type III). For accuracy of measurement, a digital vernier caliper (Aerospace Co.) with a calibrated digital micrometer, which read to the nearest 0.01 mm, was used to record the mesiodistal dimensions of the mandibular teeth [Figure 1]. The caliper was inserted from the buccal or labial embrasure area with the instrument held parallel to the occlusal surface and perpendicular to the long axis of the tooth. The mesiodistal widths of mandibular permanent teeth from the first molar in the right side to the first molar in the left side were measured. This was done in order to obtain the sum of incisors and first molars of both sides ([SIM], sum of all incisors [SI] and sum of canine and premolars [SCPM] of the right side and left side).

SI was used to predict the width of SCPM of one side from Moyer's probability chart at 75% and compared and correlated to the averaged actual value of SCPM.

SIM on X line and actual SCPM of both sides on Y line were plotted and a linear trend line was passed on this X-Y scatter which gives the regression equation on the graph for the North Indian population as $Y = a + bX$ where X (SIM) is the independent variable and Y (predicted SCPM) is the dependent variable.

Separate regression equation was formulated for males (Group I), females (Group II) and for both sexes combined (Group III). On substituting the value of X, total predicted SCPM value (right and left sides) was obtained as Y for the North Indian population sample.



Figure 1: Measuring mesiodistal width using electronic digital calipers

Similarly; SIM of the present study population sample was substituted in Melgaco regression equation to obtain SCPM using their equation. The total actual SCPM (right and left sides) were compared and correlated to the total predicted SCPM (right and left sides) obtained by the two different regression equation devised for the present study population sample and the Brazilian population respectively.

Statistical Analysis

All analyses were performed on SPSS (SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc) software. Data were summarized as Mean ± standard deviation (SD) paired observations were compared by paired *t*-test ($\alpha = 2$) while independent groups were compared by independent Student's *t*-test. Pearson's correlation was done to assess the association between the variables. A simple linear regression was used to assess relative association between the variables considering SIM the independent variable (X) and the actual SCPM as the dependent variable (Y). The level of significance was at $P < 0.05$.

Error of the Measurement

The measurements of randomly selected 30 study casts were repeated twice with 1 week interval by one investigator. All the measurements were recorded on Microsoft Excel (2007) spread sheet. Student *t*-test was carried out to compare the difference between the two measurements. Statistically insignificant differences were observed.

RESULTS

Table 1 shows the distribution and means age of different groups participated in the present study.

Table 2 shows mean values of SI, SIM, average SCPM (actual), total SCPM.

Table 3 shows the comparison between the actual and predicted width obtained from Moyer's probability chart.

Table 4 shows the regression equation devised for Group I, Group II and Group III for the North Indian population is as follows.

- $Y = 7.70 + 0.7386X$ for Group I (males)
- $Y = 13.00 + 0.6065X$ for Group II (females)
- $Y = 7.15 + 0.7450X$ for Group III (males + females).

Table 5 shows comparison of actual SCPM and predicted SCPM width obtained from the present study regression equation and Melgaco regression equation.

Table 6 shows the strength of estimations or predictions by the present study regression equation, Melgaco equation and prediction from Moyer's probability table to the actual SCPM for Group I, Group II and Group III.

Table 7 exhibits mean the difference between actual and predicted SCPM in the present study and other studies by Moyers probability chart.

Table 8 demonstrates mean difference between actual and predicted SCPM in the present study and the other studies using the same combination i.e. sum of incisors and mandibular first molars to formulate regression equation.

The scatter plots of the data show the presence of outlying values, the linearity of the relationship around the regression line. The correlation values between actual and predicted SCPM obtained in the present study for Group I, Group II and Group III were presented in Figures 2-4 respectively.

DISCUSSION

Among the population of various racial and ethnic origins, as well as different sexes, mesiodistal tooth dimensions and craniofacial characteristics differ.^[15-18] Sexual dimorphism was

Table 1: Mean age for different groups

Groups	Sex	Number of subjects (n)	Mean±SD (years)
I	Males	100	20.12±4.70
II	Females	100	19.54±3.16
III	Males+females	200	19.83±4

SD – Standard deviation

Table 2: Mean values of SI, SIM, average SCPM, total SCPM of different groups

Data	Mean±SD (mm)		
	Group I†	Group II†	Group III
SI	23.71±3.59	21.70±1.21	22.70±2.86
SIM	44.80±2.39	42.68±2.75	43.73±2.77
Average SCPM	20.39±1.11	19.44±1.13	19.91±1.21
Total SCPM	40.79±2.28	38.88±2.26	39.76±2.64

* $P > 0.05$ – Not significant; $P < 0.05$ – Significant; † $P < 0.001$ – Highly significant; SD – Standard deviation; SI – Sum of all incisors; SIM – Sum of incisors and molars; SCPM – Size of unerupted canines and premolars; SD – Standard deviation

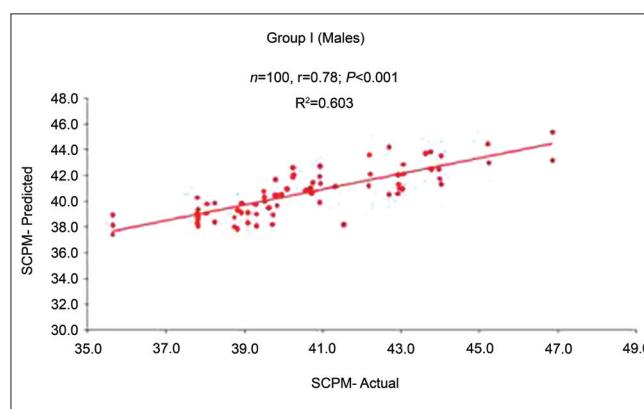


Figure 2: Correlation between actual and predicted size of unerupted canines and premolars in Group I

Table 3: Comparison of average SCPM to predicted SCPM obtained from Moyer’s probability chart

Groups	Actual SCPM	Predicted (Moyer’s) SCPM	Difference (actual-predicted) SCPM mean (in mm)	t value	P value
I	20.39±1.11	21.15±1.23	0.76±1.01	15.08	<0.001†
II	19.44±1.13	20.72±1.16	1.28±1.41	24.17	<0.001†
III	19.91±1.21	21.31±1.27	1.40±1.38	25.22	<0.001†

*P>0.05 – Not significant; P<0.05 – Significant; †P<0.001 – Highly significant; SCPM – Size of unerupted canines and premolars; SIM – Sum of incisors and molars

Table 4: Regression equations for different groups of North Indian population

Groups	Regression equation	Regression constants	
		Intercept (a)	Slope (b)
I	Y=7.70+0.7386X	7.70	0.7386
II	Y=13.00+0.6065X	13.00	0.6065
III	Y=7.15+0.7450X	7.15	0.7450

Where “X” is SIM (independent variable) and “Y” is predicted SCPM of both the sides (dependent variable). SCPM – Size of unerupted canines and premolar

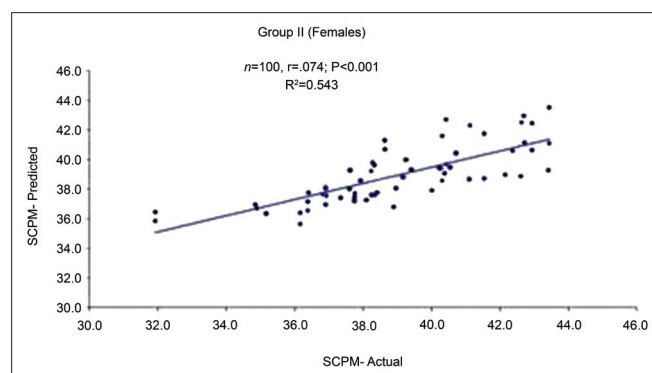


Figure 3: Correlation between actual and predicted size of unerupted canines and premolars in Group II

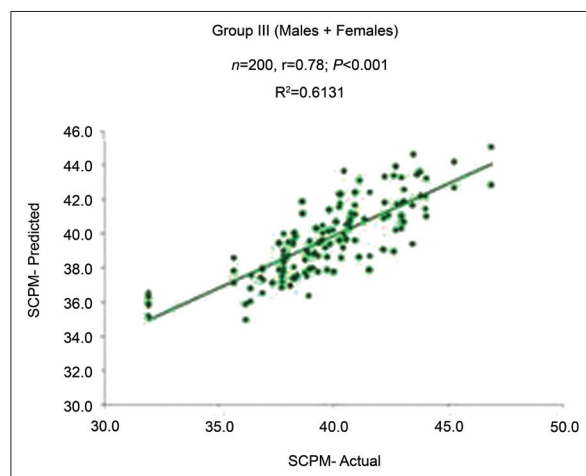


Figure 4: Correlation between actual and predicted size of unerupted canines and premolars in Group III

also confirmed in the present study; where the mean SI, SIM and SCPM showed statistically significant difference between males and females.

Nourallah et al.^[17] used different combinations of teeth and found the highest correlation when he used SIM ($r = 0.78$

for maxillary arch and 0.77 for mandibular arch) followed by the sum of upper centrals and lower first molars ($r = 0.72$ for maxillary and 0.74 for mandibular arch) and least for the sum of upper central incisors ($r = 0.61$ and $r = 0.62$). Considering this, the SIM was used to formulate regression equation in the past studies;^[16,18-20] it was also decided to be used in the present study to formulate a regression equation for North Indian population sample.

Considering racial variation of various methods of MDA was formulated for a particular race might not be applicable for another race. Hence, in the first part of the present study, it was decided to confirm the applicability and effectiveness of Moyer’s prediction table for the North Indian sample population with that established for the North European descent. The results of the present study showed that the mean difference between the average actual and the predicted SCPM values obtained from Moyer’s table were found to be statistically significant ($P < 0.001$) for the three groups. This finding was similar to previous reported studies wherein Moyer’s prediction table was used for their population^[12,21,22] [Table 7]. In contrast to this, there were few studies wherein Moyer’s method was found to be applicable at different percentile levels, but they did not compare the statistical difference between the actual and predicted SCPM at that percentiles.^[14,23,24]

As Moyer’s method is not applicable for the North Indian population therefore, it was decided to formulate a regression equation separately for males and females for the North Indian population. For formulating a regression equation; different combinations of teeth have been used in the past. Using a combination of the sum of incisors; statistically significant difference was observed between the actual and the predicted SCPM in the studies carried out by Jaroontham and Godfrey^[25] Bherwani and Fida^[26] and Ahluwalia et al.^[27] Based on these studies, it can be stated that using the sum of the lower incisors alone was not the best predictor for calculating the width of unerupted canine and premolars.

When comparing the predicted width obtained from the present study regression equation with the actual SCPM of the North Indian population sample, statistically insignificant difference was found ($P > 0.05$). This finding was also corroborated in various studies.^[16,18-20] This result suggests that regression equation formulated using SIM fulfils the requirement of obtaining an accurate prediction method wherein, statistically insignificant difference should exist between actual width and the predicted width [Table 8].

Table 5: Comparison of total actual SCPM to predicted SCPM obtained for present study regression equation and Melgaco's regression equation

Groups	Difference (actual-predicted) SCPM (North Indian sample regression) mean (in mm)	t value	P value* (NS)	Difference (actual-predicted) SCPM* Melgaco's equation mean (in mm)	t value	P value
I	0.13±0.88	0.003	>0.05	3.17±1.21	21.51	<0.001†
II	0.16±0.91	0.853	>0.05	2.15±1.15	17.39	<0.001†
III	0.15±0.97	0.228	>0.05	2.13±1.19	16.47	<0.001†

*P>0.05 – Not significant; P<0.05 – Significant; †P<0.001 – Highly significant; SCPM – Size of unerupted canines and premolars

Table 6: Correlation of actual SCPM with predicted SCPM obtained by three different methods for various groups

Groups	Studies	Correlation (r value)	Coefficient of determination (r ² value)
I	Present R.E	0.78	0.60
	Melgaco R.E	0.70	0.49
	Moyer's table	0.46	0.21
II	Present R.E	0.74	0.55
	Melgaco R.E	0.61	0.37
	Moyer's table	0.49	0.24
III	Present R.E	0.78	0.61
	Melgaco R.E	0.72	0.52
	Moyer's table	0.42	0.18

SCPM – Size of unerupted canines and premolars, R.E – Regression equation

Table 7: Mean difference between actual and predicted SCPM in present study and other studies by Moyers probability chart

Studies	Difference (actual-predicted) SCPM mean (in mm)	
	Group I (males)	Group II (females)
Present study	0.76*	1.28*
Schirmer and Wiltshire ^[12]	1.15*	0.64*
Mahmoud <i>et al.</i> study ^[21]	0.49*	0.91*
Hammad and Abdellatif study ^[22]	0.55*	0.824*

*P>0.05 – Not significant; P<0.05 – Significant; †P<0.001 – Highly significant; SCPM – Size of unerupted canines and premolars

Table 8: Mean difference between actual and predicted SCPM in the present study and the other studies

Studies	Difference (actual-predicted) SCPM mean (in mm)		
	Group I (males)	Group II (females)	Group III (males+females)
Present study	0.13±0.88*	0.16±0.91*	0.15±0.97*
Melgaco study ^[16]	0.02±1.49*	0.04±1.36*	0.00±1.44*
Mittar <i>et al.</i> study ^[19]	0.01±1.59*	0.005±1.54*	0.007±1.52*
Jaju <i>et al.</i> study ^[18]	0.02±1.62*	0.55±1.62*	-
Memon and Fida study ^[20]	0.02±0.30*	0.01±0.39*	-

*P>0.05 – Not significant; P<0.05 – Significant; †P<0.001 – Highly significant; SCPM – Size of unerupted canines and premolars

Further, racial variation was confirmed when predicted width of SCPM obtained by substituting values of SIM of the North Indian population in Melgaco regression equation showed

statistically significant difference with actual SCPM [Table 5]. Furthermore, sexual dimorphism was also confirmed in the present study [Table 6].

The strength of estimation in predicting SCPM was tested by correlation method. Table 6 shows that the highest correlation was found when using the present study regression equation followed by Melgaco regression equation and the least by Moyer's method.

Variations in the results among different studies might be attributable to different sample sizes, methods of analysis, ethnic groups and/or SDs.^[28]

To summarize the finding of the present study, it can be stated with caution that the regression equation formulated specifically for the North Indian population sample (using SIM) was by far considered to be one of the best methods of prediction amongst different methods evaluated. However, the Hixon-Oldfather, approach was considered to be the most accurate, but it is complex and many find it difficult to use.^[29-31]

These linear regression equations formulated for the North Indian population may be easy to use with no requirements of software or specific equipment for MDA. Accurate prediction of SCPM will definitely help in judging whether the space in the posterior segment is sufficient to allow the permanent teeth to erupt freely with good alignment. Based on this regression equation, prediction tables at varying values of SIM can be formulated for the North Indian population which making it simpler and easy to use. However, in future studies; regression equation should be devised for maxillary arch as well. Furthermore, the present study regression equation should be tested in a large and representative sample to confirm its predictive accuracy and consistency.

Finally, the formulation of these equations should be more beneficial for the orthodontists to establish proper diagnosis and treatment planning during the critical period of the mixed dentition stage.

CONCLUSIONS

- The proposed regression prediction equation (using SIM) formulated for the North Indian population is as follows:
 - Y = 7.70 + 0.7386X for Group I (males).

- $Y = 13.00 + 0.6065X$ for Group II (females).
 - $Y = 7.15 + 0.7450X$ for Group III (males + females).
2. Statistically significant difference was found when Moyer's probability table was used considering it to be inapplicable for the North Indian population.
 3. Statistically insignificant difference was observed between the actual and predicted SCPM using the present study regression equation considering it as one of the most accurate method among other methods.
 4. Significant difference was found when Melgaco regression equation was used, thereby confirming racial variation. Hence, using or establishing a regression equation formulated for a particular population proves to be the most accurate method of MDA.
 5. The correlation and determination coefficients found in the present study regression equation were the highest, followed by Melgaco regression equation and the least in Moyer's probability chart.

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