Original Article

DOI: 10.17354/ijss/2016/144

Prediction of Mesiodistal Width of the Mandibular Permanent Canines and Premolars by Utilizing the Mesiodistal Width of Mandibular First Permanent Molars and Incisors

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Abstract

Introduction: Prediction of mesiodistal (MD) width of unerupted permanent canines and premolars is an essential aspect of mixed dentition analysis. Several methods are used to predict tooth width. The best methods demonstrate high values of correlation and determination coefficients. In this study, we aimed to determine the linear regression equation that would predict the sum of the MD widths of mandibular permanent canines and premolars based on the sum of widths of the four mandibular permanent incisors and first permanent molars.

Materials and Methods: The sample consisted of 100 dental casts, obtained from Indian patients (50 male, 50 female, age ranges from 13 to 18 years). MD widths were measured with an electronic digital caliper. Paired and unpaired *t*-tests were used to determine measurement consistencies and the inter-examiner calibration, respectively. Unpaired *t*-test was also used to determine right/left side and sex differences. Paired *t*-test was also used to compare the predicted and actual sum of width of mandibular permanent canines and premolars.

Results: We found high values of correlation (r) and determination (r^2) coefficients (i.e., $r = 0.746$ and $r^2 = 0.557$). On average, there was no difference between predicted and actual widths of the mandibular permanent canines and premolars, and the standard errors of estimation were 1.69, 1.48, and 1.69 mm for the males, females, and the total sample, respectively.

Conclusion: The proposed method showed good accuracy and was easy to use, but it must be tested for other population.

Key words: Linear regression equations, Malocclusion, Mesiodistal diameter, Mixed dentition analysis, Prediction

INTRODUCTION

The universe of malocclusion commonly identified in orthodontics is a result of dental problems, skeletal problems, and a combination of dental and skeletal problems.[1,2] Orthodontic literature reveals that a large number of cases of malocclusion develop during the mixed dentition stage, which spans an interval from the 6th to the 12th year of life.[3-5]

The mixed dentition analysis is performed once the four permanent mandibular incisors and the first permanent molars are erupted in the oral cavity.[6,8] This analysis intends to predict the widths of unerupted permanent canines and premolars and determines the difference between the amount of dental arch space that is available and the amount of tooth material that should be accommodated. The first attempt to estimate tooth mesiodistal (MD) widths was made by Black,[9] who proposed tables based on average widths. Thereafter, many methods of predicting the MD width of unerupted canines and premolars in the mixed dentition have been reported. These methods use three

Access this article online

www.ijss-sn.com

Month of Submission : 01-2016
Month of Peer Review : 02-2016
Month of Acceptance : 02-2016
Month of Publishing : 03-2016

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distinct ways to achieve their purposes. The first employs direct measurements of the teeth from radiographs with or without the use of a prediction formula as reported by Nance,[10] Jensen *et al*.,[11] and Staley *et al*.[12] The second uses prediction tables based on the measurements of other erupted permanent teeth, as reported by Ballard and Wylie,[8] Carey,[13] Moyers,[14] Huckaba,[15] Tanaka and Johnston,[16] and Ferguson *et al*.[17] The third method involves a combination of the previous two methods, i.e., the use of prediction tables associated with the measurements of erupted and unerupted teeth, as recommended by Hixon and Oldfather,[18] Staley and Kerber,[19] Bishara and Staley,[7] Ingervall and Lennartsson,[20] and Staley *et al*.[21]

Teeth tend to have a remarkably close relationship in their proportional sizes in the same person. If a patient has large incisors, then large canines and large premolars can be expected.[4,8,14,15] In addition, there are also tooth size differences in various populations and between the sexes (males generally have larger teeth than females). Literature has shown considerable differences on form, age at eruption, and congenitally missing teeth among and within racial or ethnic groups.[22-35]

This study has been carried out to determine linear regression equations to predict the sum of the MD width of unerupted mandibular permanent canines and premolars in Indian population from Mumbai, by utilizing the width of mandibular four permanent incisors and first permanent molars as predictors.

MATERIALS AND METHODS

This study was carried out only in the mandibular arch because the arch length is generally diminished (particularly in the mandibular arch) during the transition from mixed to the permanent dentition.[10,33,43]

The sample for the present study consisted of 100 pretreatment study casts, belonging to the patients who were reported to the Department of Orthodontics for treatment and clinically having full complement of teeth till the first permanent molars.

All casts met the following criteria, as stated by many authors: permanent dentition till first permanent molar; no history of previous orthodontic treatment; all the teeth fully erupted and free of interproximal restoration, distortion, fractures, and caries; no occlusal or proximal attrition; not form, size, or number alterations; all the subjects ranged from 13 to 18 years.

All the impressions and study casts were obtained from high-quality alginate (Zhermack® clinical, Tropicalgin, a chromatic alginate impression material, ISO 1563 - ADA 18) and orthodontic model stone (Kalstone®, dental stone type III).

For accurate measurements, a digital vernier caliper (Digimatic caliper, Mitutoyo) with a 0.01 mm resolution, ±0.02 mm accuracy, and 0.01 mm repeatability (manufacturer specification) was used to measure the MD width of the teeth (Figure 1).

The digital vernier caliper was adjusted to the greatest MD diameter (contact points) of teeth, parallel to the occlusal surface and perpendicular to the long axis, according to the methods of other investigators.[4,11,17,18,37,44]

To determine the measurement consistencies, a primary investigator measured MD widths of 20 models from the first mandibular molar on one side to the first molar on the other side, 3 times at intervals of 15 days (i.e., a total of 60 models).

The inter-examiner calibration was done by a second investigator who also measured the same models twice separated by 2 weeks.

Paired and unpaired *t*-tests were used to determine measurement consistencies and the inter-examiner calibration, respectively. Unpaired *t*-test was also used to determine right/left side and sex differences. Paired *t*-test was also used to compare the predicted and actual sum of the width of mandibular permanent canines and premolars.

Pearson correlation was used to determine the correlation coefficients (*r*) between the sum of the MD widths of the mandibular permanent canines and premolars (SCPM) and the MD widths of both mandibular first permanent molars plus the MD widths of the four permanent mandibular incisors (SMI) for males, females, and both sexes.

New regression equations were calculated to determine the sum of the MD widths of the mandibular permanent canines and premolars (SCPM) for both male and female population separately and combined. The MD widths of both mandibular first permanent molars plus the MD

Figure 1: Digital vernier caliper used in the study

Table 1: Comparison of linear regression equations in various studies for males, females, and both sexes

Study	Male	Female	Male+female
Ballard and Wylie (1947)			X=9.41+0.527Y
Hixon and Oldfather (1957)			X=0.6474Y+3.493
Tanaka and Johnston (1974)			Y=9.18+0.54X
Ferguson *et al.* (1978)			Y=9.9350+0.5288X
Frankel and Benz (1986)	Y=0.72X+5.97	Y=0.49X+10.34	Y=0.64X+8.30
al-Khadra (1993)			Y=8.6+0.55 (X)
Lee-Chan (1998)			Y=7.5+0.6X
Yuen *et al.* (1998)	Y=8.22+0.58X	Y=6.66+0.64X	
Nourallah *et al.* (2002)			Y=4.93+0.52X
Diagne *et al.* (2003)	Y=5.45+0.72X	Y=8.74+0.56X	Y=5.67+0.70X
Melgaco *et al.* (2006)	Y=8.9+0.58X	Y=9.2+0.55X	
Altherr *et al.* (2007)	Y=0.59X+8.47 Y=0.35X+15.30	Y=0.65X+6.20 Y=0.47X+11.52	
Melgaco *et al.* (2007)	Y=7 + 0.824X	Y=9.2+0.766X	Y=6.55+0.829X
Uysal *et al.* (2009)	Y=4.17+0.73X	Y=4.51+0.71X	Y=3.74+0.75X
Present study (2009)	Y=0.770X+8.761	Y=0.632X+14.07	Y=0.792X+7.4

widths of the four permanent mandibular incisors (SMI) were used as predictors. Correlation and determination coefficients were also determined.

RESULTS

The results showed a significant statistical difference between the MD tooth widths of males and females (widths were generally larger in males than females). No statistically significant difference was found in tooth widths between the right and left sides. A positive correlation between the mandibular permanent canines and premolars with those of the mandibular permanent molars plus the four mandibular permanent incisors was found, which is highly significant. The linear regression equations in this study are compared with others in Table 1. The new regression equations, correlation (r), and determination (r^2) coefficients developed for males, females, and both sexes in this study are shown in Table 2.

The mean values, mean differences, standard deviations, and statistical significance for each group of teeth (SMI and SCPM) for males, females, and total sample are given in Table 2. Statistically significant differences were found between the values of SMI and SCPM. To predict SCPM based on the values of SMI, the following linear regression equation was determined:

$$Y = a + bX$$

In which, Y (dependent variable) equals the predicted sum of the MD widths of the permanent mandibular canines and premolars on both sides in millimeters

X (independent variable) equals the sum of the MD width of the four permanent mandibular incisors plus the MD widths of both mandibular first permanent molars on both the sides in millimeters.

Table 2: Mean values, mean differences, and standard deviations in millimeters for each tooth and sex group

Sex group	*n*	Mean±SD		Mean difference (SMI-SCPM)	Significance (*P* value)
		SMI	SCPM		
Male	50	46.24±2.04	44.39±2.33	1.85	0.001
Female	50	44.04±2.12	41.92±2.01	2.11	0.001
Male+ female	100	45.14±2.35	43.16±2.49	1.98	0.001

SMI: Sum of molars and incisors, SCPM: Sum of canines and premolars, SD: Standard deviation

The constant a is the y-intercept and constant b is the slope of the regression. The values of constants a and b are indicated below:

Male patients: $Y = 8.761 + 0.770X$

Female patients: $Y = 14.07 + 0.632X$

Both sexes: $Y = 7.4 + 0.792X$

Based on these new equations, predicted values for the sum of the widths of the permanent canines and premolars were obtained and compared with actual values in Table 3. A graphical representation of predicted and actual sum of widths of the permanent canines and premolars is shown in Figure 2 for both sexes.

DISCUSSION

The three measurements taken by the primary investigator were compared with paired t-test as well as ANOVA.

Table 3: Actual and predicted sum of widths of mandibular permanent canines and premolars, mean differences, and standard deviations in millimeters

Sex group	*n*	Mean±SD		Mean difference (predicted - actual values of SCPM)	Significance (*P* value)
		Actual values of SCPM	Predicted values of SCPM		
Male	50	44.39±2.33	44.37±1.57	0.025	0.920
Female	50	41.92±2.01	41.90±1.34	0.022	0.916
Male+ female	100	43.16±2.49	43.15±1.86	0.007	0.968

SCPM: Sum of canines and premolars, SD: Standard deviation

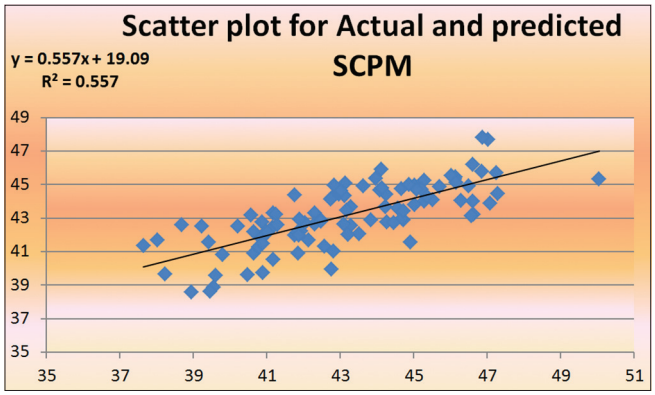

Figure 2: Actual versus predicted values of the sum of mandibular permanent canines and premolars for both sexes

No statistically significant difference ($P > 0.005$) was found between these measurements which implies great measurement precision and repeatability.

In addition, 1st and 2nd measurements of the primary and second investigator were compared with unpaired *t*-test. No statistically significant difference ($P > 0.005$) was found between the values measured by both the investigator, which were nearly the same.

Several authors found differences between male and female tooth widths.[6,11,14,29,33,37-42,47-49] In this study, we also found a statistical difference between male and female tooth widths. Males generally have larger teeth than females.

The present study shows that there was no statistically significant difference ($P > 0.005$) in the widths found between right and left sides. This implies that the widths of the teeth were same on both the sides of the arch. This symmetry was also found by other investigators.[6,16,33,37,39,41,42]

The data were analyzed separately for male and female samples. However, higher correlation and determination coefficients were found when both samples were evaluated together. These higher coefficients can be explained by the increase of sample size from 50 to 100 patients (considering both sexes).

In accordance with other studies, it seems that the combined width of only four permanent incisors is not a good prediction model for the MD widths of unerupted mandibular permanent canines and premolars.[36,37,41-50]

In this study, we found high values of correlation and determination coefficients when the MD widths of the mandibular first permanent molars were added to those of the four mandibular permanent incisors.

The values of SMI were similar to those of SCPM, with mean differences of 1.85 mm for males and 2.11 mm for females. However, these differences were statistically significant ($P < 0.001$) as shown in Table 2. Thus, simple linear regression equations were determined to predict the values of SCPM based on SMI.

The differences found between the predicted and actual values of SCPM for males, females, and combined sexes were close to zero. The mean differences were 0.025 mm for the male sample, 0.022 mm for the female sample, and 0.007 mm for the total sample (Table 3). The results show that there were minimal differences in the predicted and actual widths for the canines and premolars, which shows the reliability of the linear regression equations developed for the male, female, and total sample of the study.[51-57]

CONCLUSION

Based on the results of the study, the following conclusions were made:

1. No significant differences were found between the MD widths of the teeth on both sides of the arches.
2. There were statistically significant sex differences in tooth sizes in Indian population. Males had significantly larger teeth than their female counterpart.
3. New linear regression equations were developed to predict the sum of the MD widths of the mandibular permanent canines and premolars based on the sum of widths of the four permanent mandibular incisors and first permanent molars for the Indian population.
4. The simplified equations proposed are easy and practical to use and require no sophisticated software or specific equipment.
5. The linear regression equations were found to be reliable as no statistically significant difference was found between the predicted and actual width of the mandibular permanent canines and premolars.

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How to cite this article: Pawar RO, Bhat SR. Prediction of Mesiodistal Width of the Mandibular Permanent Canines and Premolars by Utilizing the Mesiodistal Width of Mandibular First Permanent Molars and Incisors. Int J Sci Stud 2016;3(12):178-183.

Source of Support: Nil, **Conflict of Interest:** None declared.