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The American Academy of Pedodontics/Vol. 5, No. 1

Prediction of the combined right and left canine and premolar widths in both arches of the mixed dentition

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Abstract

Presently available methods used to predict the mesiodistal widths of unerupted canines and premolars in the mixed dentition provide an estimate for the widths of one canine and two premolars which must be either doubled for the prediction of the six tooth widths on both sides of the arch, or which must be computed separately for each side of the arch. The purpose of this study was to develop, with multiple regression analysis, equations which would predict the sum of the mesiodistal widths of the right and left canines and premolars in each arch. Measurements were taken from plaster casts and periapical radiographs of the upper arch of 92 subjects (46 females and 46 males), and of the lower arch of 83 subjects (41 females and 42 males). Prediction equations were developed for sexes combined and for each sex. All equations performed satisfactorily when tested on data taken from orthodontic patients (upper arches of 43 patients and lower arches of 53 patients). Prediction equations developed from the sexes combined are recommended for clinical use.

Prediction of the mesiodistal widths of unerupted canines and premolars in mixed dentition patients is important in the diagnosis of arch length deficiency problems. Prediction methods have been developed with simple regression analysis techniques,[1-5] multiple regression analysis,[6-8] and other approaches.[9,10] Presently available methods used to predict the mesiodistal widths of unerupted canines and premolars in the mixed dentition provide an estimate for the widths of one canine and two premolars which must be either doubled for the prediction of the six tooth widths on both sides of the arch, or which must be computed separately for each side of the arch. The purpose of this study was to develop, with multiple regression analysis, equations which would predict the sum of the mesiodistal widths of the right and left canines and premolars in each arch.

Methods and Materials

A sample of normal subjects of northwest European ancestry was selected from the longitudinal records of the Iowa Facial Growth Study[11] conducted between 1946 and 1960. Measurements were taken in the upper arches of 92 subjects, 46 females and 46 males, and in the lower arches of 83 subjects, 41 females and 42 males. A sample of Caucasian orthodontic patients, treated in the Department of Orthodontics at The University of Iowa between 1961 and 1974, was collected for the purpose of cross validating the prediction equations developed from data taken from the Growth Study subjects. In the cross validation sample, measurements were taken in the upper arches of 43 patients, 27 females and 16 males, and in the lower arches of 53 subjects, 30 females and 23 males.

Measurements were taken with dial calipers[a] which measured distances to the nearest 0.05 mm. The following permanent teeth were measured on both sides of the arch on plaster casts made from alginate impressions: maxillary central incisors, canines, premolars, and first molars; mandibular incisors, canines, premolars, and first molars. Measurements were made as described by Seipel.[12] Measurements were not made when a tooth had proximal surface restorations, was distorted, not fully erupted, or otherwise unsuitable for measurement.

The mesiodistal crown widths of the permanent maxillary and mandibular canines, premolars, and molars were measured on periapical radiographs taken with a 16″-long cone paralleling or right-angle technique. Measurements were taken of teeth which were clearly visible, without distortion, and not rotated.

One investigator, R.S., took two measurements of each dimension measured in the Growth Study subjects. The same investigator took one measurement of the dimensions measured in the orthodontic patient sample. Another investigator, J.H. took two measurements of each

[a] Helios dial calipers, Fred V. Fowler Company, 315 Auburn St., Auburndale, Mass. 02166.

width measured in the maxillary arch of the Growth Study subjects. A third investigator, T.S., took two measurements of each width measured in the mandibular arch of the Growth Study subjects. The intraexaminer correlation coefficient for the measurements ranged from r = 0.94 to r = 0.99, and the intraexaminer correlation coefficients ranged from r = 0.97 to r = 0.99. The means of the measurements taken by R.S. were used in all further computations.

The mean ages of the subjects for the radiograph measurements were for the maxilla: 8.8 years (Growth Study) and 9.9 years (patient sample); and for the mandible: 9.1 years (Growth Study) and 9.6 years (patient sample). The mean ages for the cast measurements were 13.8 years for both samples in the maxilla, and in the mandible, 13.1 years (Growth Study) and 13.5 years (patient sample).

All computations were performed by a computer[b] located at the University of Iowa Computer Center. Ferguson[13] has described the basic aspects of multiple correlation.

The universal dental numbering system was used to identify the measured teeth in this article (Figure 1). An x preceding a tooth number denotes the mesiodistal width of that tooth as measured on a periapical radiograph. A tooth number standing alone denotes the width of the tooth as measured on a plaster cast.

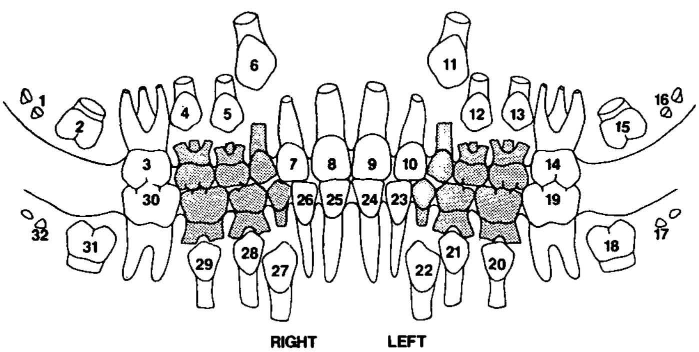

Figure 1. Universal tooth numbering system in a schema of the typical mixed dentition stage of development.

Results

Using stepwise multiple regression analysis, three prediction equations were developed for the upper and lower arches. Both sexes together were used to develop Model I equations, Model II equations were developed from female data, and Model III equations were developed from male data (Table 1).

In the upper arch, the best combination of predictor or independent variables for both sexes together numbered four, the cast width of the upper right central incisor (8), the periapical radiograph widths of the upper right second premolar (x4), the upper right canine (x6), and the upper left canine (x11). A high correlation coefficient (r = 0.92) and low standard error of estimate (0.81 mm) were obtained with the equation. Equations for each sex separately required only three predictor variables. The equation for the females had a lower correlation coefficient (r = 0.87) and higher standard error of estimate (0.92 mm) when compared with the equation for sexes combined. The equation developed for males had a high correlation coefficient (r = 0.96) and low standard error of estimate (0.64 mm). The mean differences (the differences between the predicted and actual means of the sum of the mesiodistal widths of the right and left canines and premolars) were, as expected, small and not significantly different from zero (Table 1, p values) for all three equations in the Growth Study sample.

In the lower arch, the best combination of predictor variables for both sexes together numbered four and included the cast width of the lower left central incisor (24), and the periapical radiograph widths of the lower left first premolar (x21), the lower right canine (x27), and the lower right second premolar (x29). The equation had a high correlation coefficient (r = 0.96) and low standard error of estimate (0.645 mm). Equations for each sex, as in the upper arch, required only three predictor variables. The correlation coefficients were lower than that obtained for the sexes together, and the standard errors of estimate were higher for the female equation, and lower for the male equation, when compared with the equation for sexes together. As expected, the mean differences were small and not significantly different from zero for the three equations in the Growth Study sample (Table 1).

All the prediction equations were tested on a sample of orthodontic patients (Table 1). In both arches, the Model I equations for sexes together performed most satisfactorily. The male equations performed quite well, and better than the female equations. None of the mean differences were significantly different from zero (Table 1, p values).

The Model I equations, developed with data from both sexes pooled together, were tested in each sex separately in the Growth Study and orthodontic patient samples (Table 2). The equations performed well; however, the number of subjects in the lower arch of the orthodontic patient sample was very small.

Discussion

The prediction equations developed from data taken from both sexes together, while requiring the measurement of one more predictor variable, appear to be the best equations for clinical use based on the results summarized in Table 1. The equations based on female data are not as good as those derived from both sexes together, or from the male data. The equations derived from male data appear to be quite useful. Similar differences between the sexes came to light in previous studies

[b] IBM 370/168, International Business Machines, One IBM Plaza, Chicago, Ill. 60611.

Table 1. Prediction Equations Developed from Multiple Regression Analysis

Tooth Widths Predicted (Sum of Six Teeth)	Model	Sex	Equations[1]	Growth Study Sample N	r^2	Mean Difference[3] (mm)	S.E.E.[4] (mm)	P Value[5]	Orthodontic Patient Cross Validation Sample N	r	Mean Difference (mm)	S.E.E. (mm)	P Value
4+5+6+ 11+12+13	I	M+F	$3.77+0.94(\underline{8})+2.13(\underline{X4})+1.09(\underline{X6})+0.84(\underline{X11})$	58	0.92	−0.078	0.811	0.463	19	0.92	0.064	0.715	0.701
4+5+6+ 11+12+13	II	F	$2.80+1.25(\underline{8})+1.78(\underline{X6})+1.78(\underline{X11})$	29	0.87	−0.055	0.916	0.749	14	0.83	−0.364	0.982	0.189
4+5+6+ 11+12+13	III	M	$5.44+2.93(\underline{X4})+0.90(\underline{X5})+1.26(\underline{X6})$	34	0.96	−0.031	0.644	0.780	6	0.97	0.467	0.886	0.254
20+21+22+ 27+28+29	I	M+F	$2.43+1.19(\underline{24})+2.08(\underline{X21})+1.18(\underline{X27})+1.21(\underline{X29})$	50	0.96	−0.031	0.645	0.734	7	0.94	−0.383	0.642	0.166
20+21+22+ 27+28+29	II	F	$11.135+1.87(\underline{25})+3.52(\underline{X21})-0.51(\underline{X30})$	31	0.92	−0.030	0.781	0.830	16	0.83	−0.479	1.401	0.192
20+21+22+ 27+28+29	III	M	$4.23+1.73(\underline{26})+2.04(\underline{X21})+1.67(\underline{X29})$	33	0.95	0.009	0.614	0.932	7	0.91	0.376	0.705	0.207

[1] Predictor variables are underlined; tooth number alone = cast width; tooth number preceded by X = periapical radiograph width.
[2] Pearson product-moment coefficient of correlation.
[3] Difference between predicted and actual means of the sum of the mesiodistal widths of the right and left canines and premolars; negative sign indicates the predicted mean was smaller than the actual mean.
[4] Standard error of estimate.
[5] Probability value for t-test; null hypothesis: mean difference = 0.

of these samples.[6,8]

A comparison between the equations developed in this study and other methods which predict the canine and premolar widths on only one side of the arch is not possible. However, an examination of the standard errors of estmate from other prediction methods is instructive. It is expected that the standard error of estimate will be larger for the prediction of six tooth widths than for the prediction of three tooth widths. In Table 3 the standard errors of estimate for several prediction methods are listed. The standard errors of estimate for some methods predicting three tooth widths are larger than the standard errors of estimate for the equations developed in this study for the prediction of six tooth widths (Table 3).

The equations based on a pooling of male and female data for clinical use are listed in Table 4. An example of using the lower arch equation in an eight-year-old girl will be given. The mesiodistal widths of the predictor variables were measured as follows: lower left central incisor on the cast 5.45 mm; and the periapical radiograph widths of the lower left first premolar 7.65 mm, lower right canine 6.70 mm, and lower right second

Table 2. Performance of Upper and Lower Arch Model I Equations

Tooth Widths Predicted (Sum of Six Teeth)	Arch	Sex	Growth Study Sample N	r^1	Mean Difference[2] (mm)	S.E.E.[3] (mm)	P Value[4]	Orthodontic Patient Cross Validation Sample N	r	Mean Difference (mm)	S.E.E. (mm)	P Value
4+5+6+ 11+12+13	Upper	M	30	0.94	−0.243	0.819	0.114	6	0.99	−0.245	0.591	0.356
4+5+6+ 11+12+13	Upper	F	28	0.92	0.098	0.779	0.514	13	0.91	0.207	0.742	0.335
20+21+22+ 27+28+29	Lower	M	25	0.96	−0.090	0.546	0.416	3	0.76	−0.411	0.905	0.513
20+21+22+ 27+28+29	Lower	F	25	0.93	0.028	0.738	0.851	4	0.94	−0.361	0.527	0.264

[1] Pearson product-moment coefficient of correlation.
[2] Difference between predicted and actual means of the sum of the mesiodistal widths of the right and left canines and premolars; negative sign indicates the predicted mean was smaller than the actual mean.
[3] Standard error of estimate.
[4] Probability value for t-test; null hypothesis: mean difference = 0.

Table 3. A Comparison of Standard Errors of Estimate for Several Prediction Methods

Arch	Prediction Method	Number of Tooth Widths Predicted	Standard Error of Estimate (mm)
Upper	Present Study, sexes pooled	6	0.81
Upper	Present Study, males	6	0.64
Upper	Present Study, females	6	0.91
Upper	Staley and Hoag (1978)[1]	3	0.32–0.50
Upper	Ingervall and Lennartsson (1978) 1*	3	0.65
Upper	Ingervall and Lennartsson (1978) 2*	3	0.59
Upper	Tanaka and Johnston (1974)*	3	0.86
Lower	Present Study, sexes pooled	6	0.645
Lower	Present Study, males	6	0.61
Lower	Present Study, females	6	0.78
Lower	Staley, Shelly, and Martin (1979)[1]	3	0.24–0.48
Lower	Staley and Kerber (1980)*	3	0.44
Lower	Ingervall and Lennartsson (1978)*	3	0.45
Lower	Hixon and Oldfather (1958)*	3	0.57
Lower	Tanaka and Johnston (1974)*	3	0.85

[1] Range of standard errors of estimate for several prediction equations; previously unpublished data. * Sexes pooled.

premolar 7.60 mm. The prediction equation was then solved: 2.43 + (1.19) (5.45) + (2.08) (7.65) + (1.18) (6.7) + (1.21) (7.6) = 41.9 mm, the predicted sum of the lower right and left canine and premolar widths. Because the mesiodistal widths of antimere teeth on the right and left sides of the arch are bilaterally symmetrical, halving of the predicted sum of widths would closely approximate the widths of the canine and premolars on each side of the arch. For this same reason, substitution of the antimere width for one of the predictor variables, for example, substitution of the width of tooth number 25 for tooth number 24, probably would have little adverse affect on the accuracy of the prediction equation. Obviously, the rare patient having marked bilateral asymmetry in tooth widths presents a problem for this and all tooth width prediction methods.

A 16"-long cone paralleling or right-angle radiograph technique should be used in conjunction with the prediction equations. Markedly rotated or obviously distorted tooth images should not be used in the equations. If the radiograph image of the antimere tooth is satisfactory, use the measurement of the antimere in the equation. A dial caliper is the measurement instrument of choice. The equations are solved easily with any small electronic calculator. (The prediction equations were developed from Caucasian data, and their use in other racial groups is not recommended.)

The authors wish to thank Jane R. Jakobsen for her helpful assistance with computer analysis of the data.

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Table 4. List of Prediction Equations for Clinical Use

Arch	Sex	S.E.E.[1] (mm)	r[3]	Equations[2]	Estimate of Sum of Right and Left Canines and Premolars (mm)
Upper	M+F	0.81	0.92	3.77+0.94(__)+2.13(___)+1.09(___)+0.84(___) = 8 X4 X6 X11	__________
Lower	M+F	0.64	0.96	2.43+1.19(__)+2.08(___)+1.18(___)+1.21(___) = 24 X21 X27 X29	__________

[1] Standard error of estimate.
[2] Predictor variables are identified beneath parentheses: tooth number alone = cast mesiodistal width; tooth number preceded by x = periapical radiograph mesiodistal width. [3] Pearson product-moment coefficient of correlation.