The prediction of the size of unerupted canines and premolars in a contemporary orthodontic population

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Linear regression equations for the prediction of the mesiodistal widths of unerupted canines and premolars were calculated for a large sample of recent orthodontic patients. The form of the equations, as well as the size of the various confidence belts, were generally similar to those in the widely used but incompletely characterized Michigan Mixed Dentition Analysis. Although either set of tables would seem equally appropriate, a simple approximation—half the width of the mandibular incisors plus either 11.0 for the maxillary canine-premolar segments, or 10.5 for the mandibular segments—is of comparable accuracy.

The prediction of unerupted permanent canine and premolar size in the patient with mixed dentition is central to early orthodontic diagnosis and treatment. Early attempts at estimation were based on tables of average widths, for example those of Black,[1] and they were seldom appropriate for the individual. Subsequently, two major approaches—radiographic and statistical—have been used to obtain valid estimates for a given patient.

Specific methods for estimating the approximate size of unerupted teeth from radiographs have been suggested by many workers[2-9] and, although considerable accuracy can be obtained, an exacting, time-consuming technique is generally required. These disadvantages may largely be overcome by a variety of regression schemes in which tooth size is predicted from permanent teeth that are already present and easily measured—the mandibular incisors.[10-14] Methods that are based on different combinations of teeth [11,12,15,16] or techniques[17,18] have been described; however, they are used infrequently.

Although the various reports are similar, only Moyers's scheme has achieved widespread clinical acceptance. He tabulated the various percentiles of his regression equations and presented these tables as part of a unified Mixed Dentition Analysis (MDA) in an uncommonly widely used textbook. Unfortunately, Moyers's equations, not to mention the sample from which they were calculated, have never been characterized in the literature. It may be inferred from a recent graphic validation[19] that Moyers's equations consistently underestimate the size of unerupted teeth. Moreover, a secular increase in the size of some teeth has been evidenced since Moyers's equations were calculated.[20,21]

The extent to which Moyers's charts are appropriate to a contemporary orthodontic population is examined.

Methods

Dental casts for 506 orthodontic patients in the Cleveland area were obtained from the orthodontic department of Case Western Reserve University School of Dentistry and from the records of three orthodontists practicing in the Cleveland area, Drs. Sanford Neuger, Arthur Phelps, and Milton Rabine.

To be included in the study, patients had to be of probable European ancestry and less than 20 years old. Models had to have been taken since 1966 before any orthodontic treatment, and all teeth to be measured had to be fully erupted and free of visible fractures, caries, and restorations.

Mesiodistal widths of the permanent mandibular incisors and all canines and premolars were obtained with pointed vernier calipers, and they were read to the nearest 0.05 mm according to methods outlined by Seipel[22] and Moorrees and others.[23]

The moderately high degree of linear correlation that exists among various groups of permanent teeth makes it possible to measure the total width of the permanent mandibular incisors and to predict the size of teeth that have yet to erupt. The present data were used to generate formulas—"regression" equations—that can be used clinically to effect predictions in much the same way one converts Farenheit to Celsius. Specifically, least-squares regression equations of the form $Y=A+B\ (X)$ were calculated with a programmable electronic calculator.* In these equations, Y equals the predicted size of an unerupted buccal segment (canine and premolars); X equals the measured width of the four mandibular incisors; and A and B are constants. Coefficients of linear correlation, standard errors of estimate, and confidence belts for individual predictions were calculated for each equation in the evaluation of the accuracy of the resulting formulas.

Results

Descriptive statistics for the three groups of teeth measured here are presented (Table 1).

Table 1 ■ Descriptive statistics for combined mesiodistal widths in millimeters.

Tooth group	Range	Mean	Standard deviation
Mandibular lateral & central incisors	18.5 to 28.0	23.43	1.35
Maxillary canines, first premolars, & second premolars	19.1 to 25.9	22.27	1.09
Mandibular canines, first premolars, & second premolars	18.4 to 24.9	21.76	1.12

Table 2 ■ Prediction equations.

Canine-premolar segment	Coefficient of correlation	Regression coefficients		Standard error of estimate in millimeters
		A	B	
Maxillary	0.625	10.41	0.51	0.86
Mandibular	0.648	9.18	0.54	0.85

Few subjects had incisor widths below 20.5 mm and beyond 27.0 mm in the sample.

Coefficients of correlation for the canine-premolar segments of each dental arch, and the values of A, B, and the standard errors of estimate for the two regression equations are shown (Table 2).

Percentiles for the prediction of the size of maxillary and mandibular buccal segments are presented in Tables 3 and 4 respectively. Predictions for total incisor widths of less than 20.5 mm or more than 27.0 mm were not computed because they would have involved extrapolation.

Table 3 ■ Probability table for predicting the widths of maxillary canines, first premolars, and second premolars from mandibular lateral and central incisors in millimeters.

	Mandibular lateral and central incisors													
	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0	25.5	26.0	26.5	27.0
95%	22.2	22.5	22.7	23.0	23.2	23.5	23.7	24.0	24.2	24.5	24.7	25.0	25.2	25.5
85%	21.7	21.9	22.2	22.4	22.7	22.9	23.2	23.4	23.7	24.0	24.2	24.5	24.7	25.0
75%	21.4	21.6	21.9	22.1	22.4	22.6	22.9	23.1	23.4	23.6	23.9	24.1	24.4	24.7
65%	21.1	21.4	21.6	21.9	22.1	22.4	22.6	22.9	23.1	23.4	23.6	23.9	24.2	24.4
50%	20.8	21.0	21.3	21.5	21.8	22.1	22.3	22.6	22.8	23.1	23.3	23.6	23.8	24.1
35%	20.5	20.7	21.0	21.2	21.5	21.7	22.0	22.2	22.5	22.7	23.0	23.2	23.5	23.7
25%	20.2	20.5	20.7	21.0	21.2	21.5	21.7	22.0	22.2	22.5	22.7	23.0	23.2	23.5
15%	19.9	20.1	20.4	20.7	20.9	21.2	21.4	21.7	21.9	22.2	22.4	22.7	22.9	23.2
5%	19.4	19.6	19.9	20.1	20.4	20.6	20.9	21.1	21.4	21.7	21.9	22.2	22.4	22.7

Table 4 ■ Probability table for predicting the widths of mandibular canines, first premolars, and second premolars from mandibular lateral and central incisors in millimeters.

	Mandibular lateral and central incisors													
	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0	24.5	25.0	25.5	26.0	26.5	27.0
95%	21.6	21.9	22.1	22.4	22.7	22.9	23.2	23.5	23.7	24.0	24.3	24.5	24.8	25.1
85%	21.1	21.3	21.6	21.9	22.1	22.4	22.7	23.0	23.2	23.5	23.8	24.0	24.3	24.6
75%	20.8	21.0	21.3	21.6	21.8	22.1	22.3	22.6	22.9	23.2	23.4	23.7	24.0	24.3
65%	20.5	20.8	21.1	21.3	21.6	21.9	22.1	22.4	22.7	22.9	23.2	23.5	23.7	24.0
50%	20.2	20.5	20.7	21.0	21.3	21.5	21.8	22.1	22.3	22.6	22.9	23.1	23.4	23.7
35%	19.9	20.1	20.4	20.7	20.9	21.2	21.5	21.7	22.0	22.3	22.5	22.8	23.1	23.3
25%	19.6	19.9	20.1	20.4	20.7	21.0	21.2	21.5	21.8	22.0	22.3	22.6	22.8	23.1
15%	19.3	19.6	19.8	20.1	20.4	20.6	20.9	21.2	21.5	21.7	22.0	22.3	22.5	22.8
5%	18.8	19.0	19.3	19.6	19.9	20.1	20.4	20.7	20.9	21.2	21.5	21.7	22.0	22.3

Table 5 ■ Comparison of probability tables for canines, first premolars, and second premolars: the 75th percentile.

Width of mandibular incisors (mm)	Width of maxillary canines, first premolars, and second premolars (mm)			Width of mandibular canines, first premolars, and second premolars (mm)		
	Moyers	CWRU*	Approximation	Moyers	CWRU*	Approximation
20.5	21.2	21.4	21.3	20.7	20.8	20.8
21.0	21.5	21.6	21.5	21.0	21.0	21.0
21.5	21.8	21.9	21.8	21.3	21.3	21.3
22.0	22.0	22.1	22.0	21.6	21.6	21.5
22.5	22.3	22.4	22.3	21.9	21.8	21.8
23.0	22.6	22.6	22.5	22.2	22.1	22.0
23.5	22.9	22.9	22.8	22.5	22.3	22.3
24.0	23.1	23.1	23.0	22.8	22.6	22.5
24.5	23.4	23.4	23.3	23.1	22.9	22.8
25.0	23.7	23.6	23.5	23.4	23.2	23.0
25.5	24.0	23.9	23.8	23.7	23.4	23.3
26.0	24.2	24.1	24.0	24.0	23.7	23.5
26.5	24.5	24.4	24.3	24.3	24.0	23.8
27.0	24.8	24.7	24.5	24.6	24.3	24.0

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Discussion

The regression coefficients that were calculated in the present study are remarkably similar to those of Ballard and Wylie[12] (mandible, A=9.41 and B=0.527) and Moyers[14] (by inference: maxilla, A=9.23 and B=0.55; mandible, A=7.82 and B=0.60). Indeed, all statistics were so similar that our confidence belts match Moyers's almost exactly (Table 5).

Theoretically, prediction equations should be updated from time to time because levels of α are valid only for one prediction. However, there seems to be little indication that such a procedure is warranted here. Although no significant difference is apparent between the present investigation's prediction tables and those of Moyers, the prediction of the unerupted canine-premolar regions may be simplified at the recommended 75 percentile level[19]—half the width of the mandibular incisors (in millimeters) plus 11.0 mm for the maxillary arch; and half the incisor width (in millimeters) plus 10.5 mm for the mandibular arch. This rule is a good approximation in that it is never more than a few tenths of a millimeter in error, regardless of which set of tables is used as the standard.

The incisor-buccal segment correlations that were found here (0.625 and 0.648) are almost identical to those of Ballard and Wylie[12] (mandible, r=0.64), Hixon and Oldfather[17] (mandible, r=0.69), and Bolton[13] (mandible, r=0.65).

Coefficients of linear correlation, r_{xy}, calculated between groups of teeth may, perhaps, be interpreted in terms of the so-called theory of common elements,[24] according to which r is an estimate of ρ—the proportion of size-determining elements common to both X and Y: ρ= number of elements common to X and Y/(total elements in X)(total elements in Y). In a comparison of monozygotic twins, the control of tooth size has been largely polygenically inherited, with only about 10% of the variance attributable to nutritional status.[25] It is tempting, therefore, to equate "polygenes" and "common elements" and to suggest that the consistent correlations found in the various studies may mean that about 60% to 70% of the polygenes that determine tooth size are shared by the mandibular incisors and the canines, and premolars.

Although a secular increase in some dental dimensions has been reported,[20,21] no significant effect on prediction by such a tendency could be demonstrated here. Possibly, the differences in size that are reported for contemporary filial generations are not so much an indication of secular trends as a reflection of proximal attrition.[26,27]

Summary and conclusions

The size of unerupted canines and premolars is important to the clinician in charge of the patient with a mixed-dentition. Although various methods of estimation have been proposed, Moyers's regression scheme (utilizing the buccal segments and the mandibular incisors) is widely used because of its simplicity and ease of application.

Unfortunately the form of Moyers's equations and the size of his confidence intervals have never been validated on another sample. Moreover, the possibility of secular changes during the past 20 years cannot be ruled out. Accordingly, a

study was conducted to repeat Moyers's observations on a new, large sample that was drawn from a contemporary orthodontic population. Specifically, tooth-size data were collected from study casts of 506 Cleveland-area patients.

The present findings were generally comparable to those of earlier investigators. The mandibular incisors showed a correlation of r=0.625 for the maxillary canine-premolar region and r= 0.648 for the mandibular canine-premolar region.

Prediction tables were constructed, and they were practically identical to those of Moyers. Accordingly, either set of percentiles—Moyers's or those in the present study—seem to be equally appropriate to a contemporary population. However, neither method of estimation is necessary. The size in millimeters of unerupted canines and premolars at the 75th percentile can be predicted by taking half the width of the mandibular incisors and adding 11.0 for the maxillary teeth and 10.5 for the mandibular teeth.

This paper is based on a thesis submitted in partial fulfillment of the requirements for the MS degree, Case Western Reserve University. The investigation was aided by PHS-NIH General Research Support Grant 5335.

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*Model 9100A, Hewlett-Packard, Loveland, Colo, 80537.

1. Black, G.V. Descriptive anatomy of the human teeth, ed 4. Philadelphia, S. S. White Dental Mfg. Co., 1897, p 16.

2. McCoy, J.D. Indications for the use of the x-ray in orthodontics. Int J Orthod 3:483 Aug 1917.

3. Simpson, C.O. When radiography is used to the greatest advantage in orthodontics. Int J Orthod Oral Surg 9:699 Sept 1923.

4. Nance, H.N. *The limitations of orthodontic treatment. I.* Mixed dentition diagnosis and treatment. Am J Orthod Oral Surg 33:177 April 1947.

5. Foster, H.R., and Wylie, W.L. Arch length deficiency in the mixed dentition. Am J Orthod 44:464 June 1958.

6. Bull, R.L. Radiographic method to estimate the mesiodistal dimension of unerupted teeth, abstract. Am J Orthod 45:711 Sept 1959.

7. Cohen, M.I. Recognition of the developing malocclusion. Dent Clin North Am 6:299 July 1959.

8. Huckaba, G.W. Arch size analysis and tooth size prediction. Dent Clin North Am 11:431 July 1964.

9. Moorrees, C.F.A., and Reed, R.B. Correlations among crown diameters of human teeth. Arch Oral Biol 9:685 Nov-Dec 1964.

10. Carey, C.W. Linear arch dimension and tooth size. Am J Orthod 35:762 Oct 1949.

11. Griewe, P.W. Tooth size and symmetry in the human dentition, MS thesis. State University of Iowa, School of Dentistry, Iowa City, 1949.

12. *Ballard, M.L., and Wylie, W.L. Mixed dentition case analysis*—estimating size of unerupted permanent teeth. Am J Orthod 33:754 Nov 1947.

13. Bolton, W.A. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 28:113 July 1958.

14. Moyers, R.E. Handbook of orthodontics; for the student and general practitioner. Chicago, Year Book Medical Publishers, 1958, p 146.

15. Brown, J.E. Predicting the mesiodistal crown width of unerupted maxillary canines, first and second premolars, MS thesis —University of Tennessee, School of Dentistry, Memphis, 1955.

16. Fonseca, C.C. Predicting the mesiodistal crown width of *the canine-premolar segments of maxillary dental arches*, MS thesis. University of Tennessee, School of Dentistry, Memphis, 1961.

17. Hixon, E.H., and Oldfather, R.E. Estimation of the sizes of unerupted cuspid and bicuspid teeth. Angle Orthod 28:236 Oct 1958.

18. Stähle, H. Determination of mesiodistal crown width of unerupted permanent cuspids and bicuspids. Helv Odontol Acta 3:14 April 1959.

19. Moyers, R.E. Handbook of orthodontics; for the student and general practitioner. ed 3. Chicago, *Year Book Medical Publishers*, 1973, p 369.

20. Garn, S.M.; Lewis, A.B.; and Walenga, A. Evidence for a secular trend in tooth size over two generations. J Dent Res 47: 503 May-June 1968.

21. Lavelle, C.L.B. Secular trends in different racial groups. Angle Orthod 42:19 Jan 1972.

22. Seipel, C.M. Variation of tooth position. A metric study of the variation and adaptation in the deciduous and permanent dentitions. Svensk Tandlak Tidskr 39 Suppl 1946, p 26.

23. Moorrees, C.F.A., and others. Mesiodistal crown diameters of the deciduous and permanent teeth in individuals. J Dent Res 36:39 Feb 1957.

24. *Snedecor, G.W. Statistical methods; applied to experiments* in agriculture and biology. ed 5. Ames, Iowa State University Press, 1956, p 170.

25. Garn, S.M.; Lewis, A.B.; and Kerewsky, R.S. Genetic, nutritional, and maturational correlates of dental development. J Dent Res 44:228 Jan-Feb Suppl 1965.

26. Begg, P.R. Stone Age man's dentition with reference to anatomically correct occlusion, the etiology of malocclusion, and a technique for its treatment. Am J Orthod 40:298 April 1954.

27. Murphy, T.R. Reduction of the dental arch by approximal attrition. A quantitative assessment. Br Dent J 116:483 June 1964.