Prediction of Breadth of Permanent Canines and Premolars in the Mixed Dentition

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The possibility of predicting the breadths of unerupted canines and premolars is important in the supervision of the development of the dentition. Lack of space implies crowding and indicates that treatment will be necessary. Early prediction of lack of space facilitates treatment so that serial extraction can be started.

Various methods have been used for estimating the breadths of unerupted permanent canines and premolars:

1. roentgenographic breadths of the unerupted teeth,
2. mean breadth of the teeth,
3. the breadth of the canine and premolars as judged from the total breadth of the lower incisors.

The first method has the disadvantage that the image is somewhat enlarged and also that the tooth germ may be rotated with the result that the roentgenogram will give a false impression of its breadth.

The second method implies a serious risk of misjudging the space available after eruption of the teeth since the sum of the breadths of the canine and the premolars varies between 19 and 25 mm. It is true that the mean value can be modified if the permanent teeth (incisors and first molars) already erupted are large, but the method is inexact. Several textbooks of orthodontics[5,13] therefore recommend the third method which is based on the intraindividual correlation in tooth size.

A combination of the breadths of the roentgenographic images of lower premolars and the breadths of erupted lower incisors as a basis for estimation of the total breadth of the lower canine and premolars has been recommended by Hixon and Oldfather.[7] They found such a combination to permit better prediction than methods previously available, but their method has apparently not found wide use.

Since the possibility of predicting the breadths of unerupted canines and premolars is clinically important and since such prediction can probably be improved by the combination of different predictors, it was considered of interest to try modifications of the method used by Hixon and Oldfather. The best predictors can be readily selected with the use of stepwise multiple regression. The purpose of the present investigation was to investigate, with the aid of multiple regression, which parameters of the mixed dentition were most useful for predicting the breadths of unerupted canines and premolars.

MATERIAL AND METHODS

The material consisted of 77 children (38 boys and 39 girls), aged 9 years, 1 month to 10 years, 10 months (mean 10 years, 1 month). When the children were first seen the first permanent molars and the permanent incisors had erupted to occlusion, while the permanent canines and premolars were unerupted.

At the first examination alginate impressions of both jaws were taken and stone casts were made. Intraoral roentgenograms were obtained of the permanent canines and premolars, from the right side in 38 randomly selected children and on the left side in the remaining 39.

A modified "bisecting the angle"

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technique[6] was used for the roentgen examination. By the use of a cotton roll or bite block the examiner attempted to obtain parallelism between the tooth and the film after which the central roentgen ray was adjusted to impinge upon the middle of the film perpendicular to the bisectrix of the angle between the longitudinal axis of the tooth and the plane of the film. To obtain an orthoradial projection three intraoral roentgenograms were taken of the canine, first premolar, and second premolar. The roentgen machine was equipped with a long cone with a distance of 25 cm between the focus and the tip of the cone.

The mesiodistal breadth of each first permanent molar and those of the incisors were measured on the casts, as was the buccolingual breadth of the first permanent molars. The mesiodistal breadth was measured between the anatomic contact points, parallel to the occlusal plane *ad modum* Lundström.[10] The buccolingual breadth was measured as the maximal distance between the buccal and the lingual surfaces perpendicular to the mesiodistal diameter of the tooth and parallel to the occlusal plane, if necessary down to the border of the gingiva on the cast. All measurements were made to the nearest tenth of a millimeter with well-ground sliding calipers. The mesiodistal breadths of the crowns of the permanent canines and premolars were measured in the roentgenograms. The measurements were made to the nearest tenth of a millimeter with a caliper compass and a transverse scale. The roentgenograms were also used for estimating the degree of rotation of the unerupted premolars.

The rotation of the premolars was estimated from the distance between the buccal and lingual cusps. The distance between the tips of the cusps perpendicular to the longitudinal axis of the tooth was measured. If the distance was 0-1 mm, the degree of rotation was said to be 1; if 1.1-2.0 mm, 2; and if it was more than 2.0 mm, the degree of rotation was said to be 3. Rotation of degree 1 was most common (150 teeth) followed by degree 2 (91 teeth) and 3 (67 teeth). The distribution of teeth with degree 2 and degree 3 rotation among the various sorts of teeth is given in Table I.

TABLE I

Distribution of teeth with rotation degrees 2 and 3.

	Degree of rotation	
Tooth	*2*	*3*
5+5	19	18
4+4	26	19
5—5	21	19
4—4	25	11

When all the permanent canines and premolars had erupted to occlusion, new casts were made of the dental arches, and the mesiodistal breadth of each canine and premolar was measured in the way described above.

The breadths of the individual teeth in the original casts and of the canines and premolars in the roentgenograms were used as predictors of the mesiodistal breadths of the permanent canines and premolars. The total breadths of the upper and the lower incisors, respectively, were also used as predictors. In step 1 the program used selects the predictor variable with the greatest value for prediction of the dependent variable and in step 2 and subsequent steps the next most useful variable. Since the regression is linear, a multiple normal distribution is presumed for statistical test.

RESULTS

The sizes of the teeth in the casts are given in Table II.

In the prediction of the breadth of an individual, unerupted permanent canine or premolar, the breadth of the homologous tooth invariably proved

Upper permanent teeth	M	S.D.	Range	Lower permanent teeth	M	S.D.	Range
Mesio-distal							
First molar	10.6	0.5	9.3-11.9	First molar	11.3	0.7	9.7-13.0
Second premolar	6.9	0.4	5.3-7.7	Second premolar	7.4	0.4	6.5-8.5
First premolar	7.2	0.4	6.2-8.3	First premolar	7.3	0.4	6.3-8.4
Canine	8.0	0.5	7.1-9.0	Canine	7.0	0.4	6.1-8.1
Lateral incisor	7.0	0.6	5.0-8.4	Lateral incisor	6.2	0.3	5.6-7.3
Central incisor	9.0	0.6	7.5-10.4	Central incisor	5.6	0.3	4.9-6.3
Bucco-lingual							
First molar	11.6	0.6	10.2-13.1	First molar	10.8	0.5	9.6-11.7
Total mesio-distal breadth							
Upper incisors	32.0	2.1	27.2-37.0	Lower incisors	23.6	1.1	21.4-26.8
Upper canine and premolars	22.0	1.0	19.7-24.7	Lower canine and premolars	21.6	0.9	19.4-23.5

TABLE II

Mean (M), standard deviation (S.D.), and range of variation in mm of breadths of teeth measured on casts of 77 children. Right and left sides pooled and sexes combined.

best. The determination coefficient, R^2 (Table III), shows that about half of the variance in breadth of the upper second premolar can be explained by the breadth of the homologous tooth, while three fourths of the variance in breadth of the lower second premolar can be explained by the breadth of the homologous tooth.

With three predictors it is possible to explain 62 percent of the variance of the total breadth of the upper canine and premolars. The regression equation is as follows:

(1) Total breadth of upper canine and premolars = 4.77 + 0.55 × buccolingual breadth of upper first molar + 0.73 × roentgenographic breadth of upper first premolar + 0.58 × roentgenographic breadth of upper canine. For the equation the standard error of estimate about the regression line is 0.65 mm.

TABLE III

Determination coefficients (R^2) in prediction of mesiodistal breadth of permanent canines and premolars with the breadth of the homologous tooth.

Upper tooth	R^2	*Lower tooth*	R^2
Second premolar	0.52	Second premolar	0.76
First premolar	0.72	First premolar	0.70
Canine	0.86	Canine	0.81

Figure 1 compares the observed values of the total breadth of the upper canine and premolars and the values calculated from the equation. It is clear that the agreement between the observed and the calculated values was relatively good over the entire range of variation. The calculated values, however, tended to be too small in the upper part of the range of variation of the dependent variable and somewhat too large in the lower. When equation 1 was used the residuals in a probability plot showed a good normal distribution.

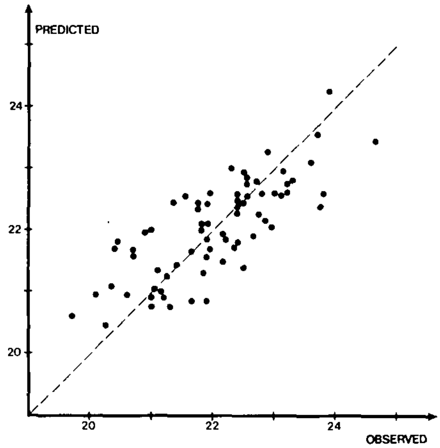

Fig. 1 Agreement between observed values of the total breadth of the upper canine and premolars and values predicted with equation 1. For an observed value (x-axis) the corresponding predicted value can be read on the y-axis.

If individuals with rotation degree 3 of the unerupted upper premolars are not included in the calculations, it will result in an increase of the value found for the determination coefficient.

If cases with rotation degree 3 of unerupted upper premolars are excluded, the regression equation is:

(2) Total breadth of upper canine and premolars = 2.5 + 1.23 × roentgenographic breadth of upper first premolar + 0.5 × buccolingual breadth of upper first molar + 0.55 × roentgenographic breadth of upper second premolar.

For equation 2 the standard error of estimate about the regression line is 0.59 mm. The equation explains 72 percent of the variance of the total breadth of the upper canine and premolars. There was no tendency for any systematic differences between observed and calculated values when equation 2 was used. The residuals showed a fair normal distribution.

The measurements of the roentgenographic breadths of the unerupted teeth can explain 78 percent of the variance of the total breadth of the lower canine and premolars. The regression equation is:

(3) Total breadth of lower canine and premolars = 4.49 + 1.14 × roentgenographic breadth of lower first premolar + 0.62 × roentgenographic breadth of lower canine + 0.47 × roentgenographic breadth of lower second premolar. The standard error of estimate about the regression line is 0.45 mm (equation 3).

Comparison between the observed values and those calculated from the equation showed that the calculated value tended to be about 0.5 mm too small in the upper part of the range of variation. With a calculated value exceeding 22 mm one should therefore add 0.5 mm to avoid underestimation of the total breadth of the canine and the premolars. The probability plot of the residuals showed a good normal distribution.

If cases with a pronounced rotation of the unerupted lower premolars had not been included, it would have meant only an insignificant increase of the determination coefficient (with three predictors from 0.78 to 0.81).

If the upper and lower first premolars have erupted so their mesiodistal breadths can be measured, it is possible to predict three fourths of the total breadth of the canines and the premolars solely with the first premolar as predictor. The determination coefficient was 0.76 for the upper jaw and 0.73 for the lower and the regression equations:

(4) Total breadth of upper canine and premolars = 6.25 + 2.19 × mesiodistal breadth of upper first premolar. The standard error of estimate about the regression line was 0.49 mm (equation 4).

(5) Total breadth of lower canine and premolars = 7.15 + 1.99 × mesiodistal breadth of lower first premolar.

The standard error of estimate about the regression line was 0.49 (equation 5).

Comparison between the observed values and those calculated from equations 4 and 5 revealed no systematic deviation for any part of the range of variation. A probability plot of the residuals showed a good normal distribution whether equation 4 or 5 was used.

Discussion

The sizes of the teeth, both the mesiodistal breadths and the buccolingual breadths, were identical or very similar to those in other Swedish series.[4,9,14] The material may therefore be regarded as representative of the Swedish population.

No endeavour was made to test the deciduous teeth as predictors of the breadths of unerupted premolars and permanent canines, since it has been shown that the correlation between the breadths of deciduous teeth and permanent teeth is weaker than that between the breadths of permanent teeth.[7] Moreover, one or more of the deciduous teeth is often missing because of premature extraction or exfoliation. Any prediction of the sizes of unerupted teeth from the sizes of deciduous teeth could therefore not be used on all children.

Since the material consisted of as many boys as girls, the regression equations hold for individuals of both sexes. In addition, earlier investigations have also shown that the use of both sexes together is possible without impairment of the results in the calculation of correlations between the sizes of teeth.[12,15]

At least three fourths of the variance of the total breadth of the lower premolars and the canine can be explained by measurement of the breadths of the teeth in intraoral roentgenograms without it being necessary to make allowance for rotated unerupted premolars. The prediction of the total breadth with equation 3 is therefore to be preferred to the use of the mean value for the breadths of the unerupted teeth.

The possibility of predicting the total breadth of the upper premolars and the canine with the aid of a few predictors is not so good as for the lower teeth in cases with severe rotation of the unerupted premolars. If such rotation is at most moderate, the possibility of predicting is substantially better and the determination coefficient then almost approaches that in the lower jaw. Prediction of the total breadth of the premolars and the canine from equation 2 is therefore better than the use of the mean values. If great accuracy is required in the prediction of the space available in the upper jaw, equation 1 can be used in patients with rotated unerupted premolars.

Estimation of the space available is often undertaken in a stage of development of the dentition where eruption of the premolars and canines has already started. In the upper jaw the first premolar usually erupts before the canine and second premolar.[8] If the upper premolar has erupted, three fourths of the variance in the total breadth of the premolars and the canine can be explained by the use of the breadth of the first premolar as a predictor (equation 4). Table IV can then be used; it gives the predicted value of the total breadth when the breadth of the first premolar is known.

In the lower jaw the canine often erupts earlier than the premolars. Knowledge of the breadth of the canine is, however, not so useful for predicting the total breadth of the three teeth to warrant its use as a predictor in clinical practice. The breadth of the lower first premolar is, however, useful as a predictor. If the first premolar can be measured, about three fourths of the variance of the total breadth can be

Breadth of upper first premolar	Total breadth of upper canine and premolars	Breadth of upper first premolar	Total breadth of upper canine and premolars	Breadth of upper first premolar	Total breadth of upper canine and premolars
6.0	19.4	7.0	21.6	8.0	23.8
6.1	19.6	7.1	21.8	8.1	24.0
6.2	19.8	7.2	22.0	8.2	24.2
6.3	20.0	7.3	22.2	8.3	24.4
6.4	20.3	7.4	22.5	8.4	24.6
6.5	20.5	7.5	22.7	8.5	24.9
6.6	20.7	7.6	22.9		
6.7	20.9	7.7	23.1		
6.8	21.1	7.8	23.3		
6.9	21.4	7.9	23.6		

TABLE IV

Prediction of total breadth of upper canine and premolars with mesiodistal breadth of upper first premolar as predictor (6.25 + 2.19 × mesiodistal breadth of upper first premolar).

Breadth of lower first premolar	Total breadth of lower canine and premolars	Breadth of lower first premolar	Total breadth of lower canine and premolars	Breadth of lower first premolar	Total breadth of lower canine and premolars
6.0	19.1	7.0	21.1	8.0	23.1
6.1	19.3	7.1	21.3	8.1	23.3
6.2	19.5	7.2	21.5	8.2	23.5
6.3	19.7	7.3	21.7	8.3	23.7
6.4	19.9	7.4	21.9	8.4	23.9
6.5	20.1	7.5	22.1	8.5	24.1
6.6	20.3	7.6	22.3		
6.7	20.5	7.7	22.5		
6.8	20.7	7.8	22.7		
6.9	20.9	7.9	22.9		

TABLE V

Prediction of total breadth of lower canine and premolars with mesiodistal breadth of lower first premolar as predictor (7.15 + 1.99 × mesiodistal breadth of lower first premolar).

explained. The total breadth can then be predicted with the aid of equation 5 and Table V.

Neither in the prediction of the total breadth of the upper nor lower premolars and canine was the total breadth of the incisors of any significance. The investigation thus produced no evidence in support of those methods based on the total breadths of the lower incisors.[2,3,11,15] For predicting the total breadth of the lower premolars and the canine Hixon and Oldfather[7] recommend a combination consisting of the roentgenographic breadths of the unerupted lower premolars and measurement on the cast of the breadths of the lower central and lateral incisors. The results of the present investigation are in fairly good agreement with those obtained by Hixon and Oldfather since both procedures include measurement of the breadths of the unerupted premolars as predictors. Our results differed from theirs, however, in that the roentgenographic breadth of the lower canine was also used as a predictor. The difference may perhaps be due to differences in roentgen technique or to the possibility of differences between relations in tooth size between different populations.[1]

The investigation showed that the best variables available as predictors in the early mixed dentition are the roentgenographic breadths of the teeth in question. This is in agreement with the conclusions of Moorrees and Reed[12] and Arya et al.[1] who showed that the correlations between the breadths of teeth measured on casts are too weak to be of any practical value for prediction. In the present investigation, however, the buccolingual breadth of the first permanent molar was also used as a predictor and proved useful in the prediction of the total breadth in the upper jaw.

SUMMARY

Multiple stepwise regression was used in the selection of mixed dentition variables capable of predicting the total breadth of the unerupted permanent canine and premolars. The material consisted of 77 children. Stone casts were made before and after eruption of the canines and premolars. At the first examination when the children were, on the average, 10 years old, intraoral roentgenograms were otbained of the canine and the premolars.

To predict the total breadth of the upper canine and premolars the buccolingual breadth of the upper first permanent molar and measurements on roentgenograms of the breadths of the upper canine and premolars proved most useful. In the prediction of the total breadth of the lower canine and premolars the best results were obtained with measurement of the breadths of the teeth in the roentgenograms. The breadth of the incisors proved less useful as a predictor of the breadths of unerupted canines and premolars.

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