Mixed dentition analysis for Hong Kong Chinese

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Predicting mesiodistal crown diameters of the permanent canines and premolars is an essential diagnostic procedure.[1-4] In instances of arch-tooth discrepancies, treatment decisions can be affected by prediction values that differ by as little as 1 or 2 mm.[2]

Different methods of predicting the sizes of permanent canines and premolars have been published. One method involves using average tooth sizes from published data.[5,6] Another method bases predictions on the size of radiographic images of the permanent teeth alone or in combination with crown diameters measured on dental casts.[3,4,6-8] One widely used method advocates the use of mesiodistal crown diameters of erupted mandibular permanent incisors as the predictor for the size of unerupted canines and premolars. Other less popular methods are also mentioned in the literature.[3,9]

Prediction methods based on crown diameters of erupted permanent teeth and/or dimensions of radiographic images of unerupted teeth usually employ simple or multiple linear regressions.[7,8,10-17] The use of several predictors in multiple linear regression may improve the prediction. However, if an appropriate predictor is chosen for simple linear regression analysis, accuracy can still be acceptable.[4] Among the different methods available, Moyers' probability tables[11] and the prediction equations of Tanaka

Abstract

Using simple linear regression analyses, prediction equations for the combined mesiodistal crown diameters of canines and premolars based on lower incisor size were generated from 97 Hong Kong Chinese (51 males and 46 females, average age 12.31 years) out of a sample of 112. The mesiodistal crown diameters of the permanent teeth were measured using calipers and recorded to the nearest 0.01 mm. Significant sex differences were found for the combined diameters of the canine-premolar segments. The coefficients of correlation between combined diameters of canines and premolars and lower incisors ranged from 0.65 to 0.79. Significant sex differences of the regression equations were found and thus four simple linear regression equations were generated. Coefficients for the slope ranged from 0.58 to 0.66, and coefficients for the intercept ranged from 6.66 to 8.82. The R^2 values, standard errors of estimate, and absolute mean errors revealed that prediction models for females were less precise than those for males. Probability tables were constructed from the results of the present study. The prediction equations were found to differ from those of Tanaka and Johnston.[7] Accuracy in the mixed dentition analysis for southern Chinese would be improved by applying the prediction equations or probability tables generated from the present study.

Key Words

Mixed dentition analysis • Prediction equations • Probability tables

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Table 1
Combined mesiodistal crown diameters (mm) for unilateral permanent canine-premolars and four mandibular permanent incisors

Tooth Group	Sex	N	Mean	SD	Range	Sex difference (M-F)	% Dimorphism
$UCPm_1Pm_2$	M	46	23.371	1.100	21.075-26.200	0.695*	3.1
	F	40	22.676	1.090	20.478-25.220		
$LCPm1Pm_2$	M	50	22.301	0.960	20.168-24.748	0.718*	3.3
	F	43	21.583	1.165	18.445-23.560		
LI_1I_2	M	60	23.158	1.254	20.970-26.620	-0.124	-0.5
	F	48	23.282	1.229	20.275-25.615		

* Statistically significant sex difference at $p<0.01$.

Table 2
Simple linear regression analyses of combined mesiodistal crown diameters of unilateral permanent canine-premolars on combined mesiodistal crown diameters of mandibular permanent incisors

Variables Y	X	Sex	N	Regression coefficient A	p (A)*	B	p (B)**	R^2	Standard error of estimate
$UCPm_1Pm_2$	LI_1I_2	M	46	7.97	<0.001	0.66	<0.001	0.626	0.68
$UCPm_1Pm_2$	LI_1I_2	F	38	8.30	0.005	0.61	<0.001	0.425	0.81
$LCPm_1Pm_2$	LI_1I_2	M	50	8.82	<0.001	0.58	<0.001	0.600	0.61
$LCPm_1Pm_2$	LI_1I_2	F	41	6.66	0.011	0.64	<0.001	0.479	0.82

* *p*-value associated with the intercept of the regression line.
** *p*-value associated with the slope of the regression line.

and Johnston[7] are the most widely used.

Most prediction methods were developed from studies of Caucasian populations.[4,7,8,10,12,13,15] The applicability of these tables to other ethnic groups has been studied and found wanting.[9,18-20] The Prince Philip Dental Hospital uses Moyers' probability table (at 75th percentile) and prediction equations modified from Tanaka and Johnston. Ling[21] studied 459 12-year-old Hong Kong Chinese and adopted a value of 0.5 for the coefficient *B* of the prediction equation (see Abbreviations, below) and recalculated the different values of constant *A* for both sexes and both arches. The application of Moyers' probability table and the modified equations of Tanaka and Johnston to the local Chinese population may have undermined the accuracy of the predictions because the prediction models for Hong Kong Chinese may differ from those for Caucasians. The aims of the present study were to derive prediction equations and probability tables for the combined mesiodistal crown diameters of the canine and premolars on one side of the arch from that of the four lower incisors for Hong Kong Chinese using simple linear regression.

Abbreviations

The following abbreviations are used in this paper:

$UCPm_1Pm_2$–Combined mesiodistal crown diameters of upper permanent canine and first and second premolars on one side of the arch.

$LCPm_1Pm_2$–Combined mesiodistal crown diameters of lower permanent canine and first and second premolars on one side of the arch.

LI_1I_2–Combined mesiodistal crown diameters of the four lower permanent incisors.

$Y=A+BX$–Simple linear regression equation, where Y is the dependent variable $UCPm_1Pm_2$ or $LCPm_1Pm_2$ as specified, X is the independent variable LI_1I_2, A is the coefficient for the Y-intercept of the regression line, and B is the coefficient for the slope of the regression line.

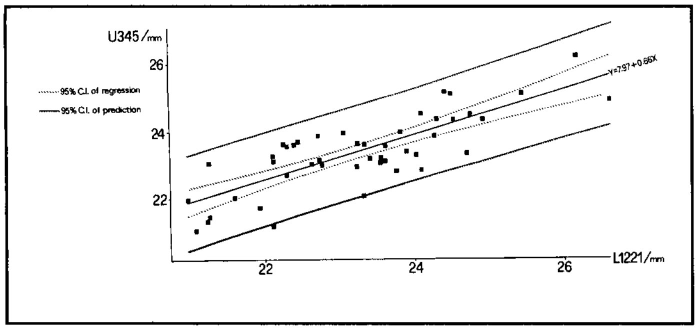

Figure 1

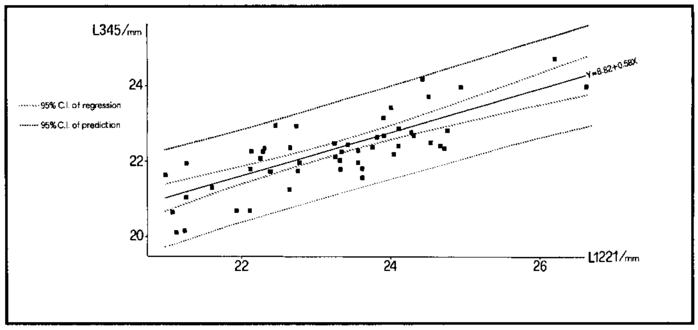

Figure 2

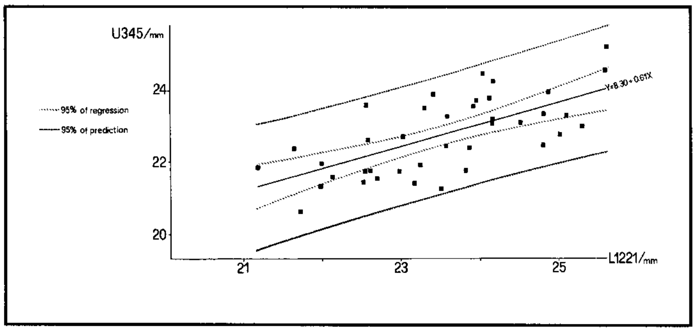

Figure 3

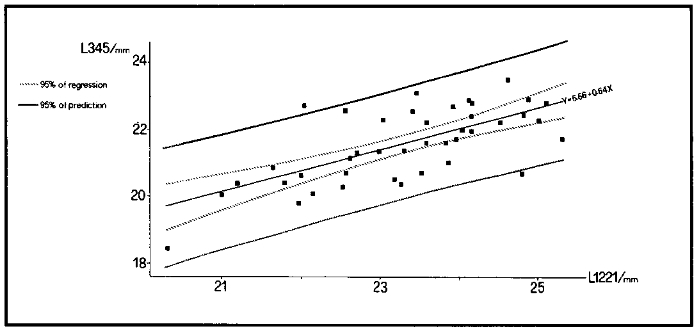

Figure 4

Figure 1
Regression of combined mesiodistal crown diameters of maxillary canine and premolars on combined mesiodistal crown diameters of mandibular incisors for males

Figure 2
Regression of combined mesiodistal crown diameters of mandibular canine and premolars on combined mesiodistal crown diameters of mandibular incisors for males

Figure 3
Regression of combined mesiodistal crown diameters of maxillary canine and premolars on combined mesiodistal crown diameters of mandibular incisors for females

Figure 4
Regression of combined mesiodistal crown diameters of mandibular canine and premolars on combined mesiodistal crown diameters of mandibular incisors for females

Materials and methods

The sample consisted of 112 Chinese children (61 males and 51 females, mean age 12.31 years, SD 0.83) drawn from 977 participants of the survey of 5-year-olds conducted by the Department of Children's Dentistry and Orthodontics, Faculty of Dentistry, the University of Hong Kong, 1986-1988. The 977 children (520 males and 457 females) in the study were randomly selected to represent the population of southern Chinese 5-year-olds in Hong Kong.[22] During 1992-93, a resurvey of these children was scheduled for an odontometric study of the mesiodistal crown diameters of primary and permanent teeth of Hong Kong Chinese. A total of 777 children were excluded for one or more of the following reasons: dental caries or restorations involving the interproximal surfaces of the primary teeth; unable to contact; emigrated; or undergoing orthodontic treatment. Of the remaining 200 subjects, 88 refused or did not show up for the appointment. Hence, the study sample consisted of 112 subjects. Impressions were taken, and the mesiodistal crown diameters of the permanent teeth were measured on the dental casts.

Mesiodistal crown diameters of the permanent teeth were measured by the first author using calipers (TESA Digit-Cal SM) with digital output to the nearest 0.01 mm, according to the method described by Moorrees and co-workers.[23] Teeth were excluded if they were partially erupted, had proximal caries or restorations, were malformed, or were damaged. Each tooth was measured twice and the average of the two readings was taken as the dimension for that individual tooth. Crown diameters of the antimeric teeth were averaged and used as the dimension of that tooth type for subsequent statistical analyses. Statistical analyses were performed using the SAS/STAT (SAS Institute Inc, Cary, NC) program.

Simple regression analysis was performed using data from 97 subjects (51 males, 46 females) where measurement of both the dependent ($UCPm_1Pm_2$ or $LCPm_1Pm_2$) and independent (LI_1I_2) variables were possible.

Results

Representativeness of the sample

Mesiodistal crown diameters of the permanent teeth were measured on 112 children (studied sample) who represented only 11.5% of the starting sample of 977. At the time of the survey of 5-year-olds, the starting sample and the studied sample were comparable in terms of age, sex distribution, and primary crown dimensions. Since the starting sample was representative of 5-year-old southern Chinese children of Hong Kong in 1986-88, the studied sample could be taken as a representative cohort of southern Chinese children who had grown from 5 years old to 12 years from 1986 to 1993.

Method error

Measurement error was assessed by the method of Dahlberg.[24] Duplicate measurements at 3-month intervals were made on 25 sets of

Table 3
Differences (mm) between true and predicted values and absolute mean errors (mm) of the dependent variables

Dependent variable	Sex	SD for difference	Absolute mean error	% of observation with absolute error <0.500	0.501-1.000	>1.000
$UCPm_1Pm_2$	M	0.672	0.665	45.7	43.5	10.9
	F	0.804	0.786	39.5	36.8	23.7
$LCPm_1Pm_2$	M	0.604	0.601	50.0	44.0	6.0
	F	0.812	0.801	53.7	26.8	19.5

dental casts randomly drawn from the studied sample. The method error for the measurement of individual permanent teeth ranged from 0.04 mm to 0.11 mm, with a mean of 0.07 mm (standard deviation = 0.1 mm). The method error for measuring groups of five permanent teeth (from central incisor to second premolar) was 0.17 mm.

Combined mesiodistal crown diameters of canine-premolar and lower incisor groups

Normality of the distribution of the variables for the two sexes was assessed using the Shapiro-Wilk test. None of the p-values was smaller than 0.05, therefore the distributions were reasonably normal and parametric statistical methods were employed for subsequent analyses. The canine-premolar segments in both arches were statistically larger in males than in females by about 3% ($p<0.01$). Table 1 lists the descriptive statistics, sex differences, and percentage sexual dimorphism for the tooth groups.

Simple linear regression analysis

The correlation coefficients between the independent variable (LI_1I_2) and dependent variables were 0.79 (for UCPm1Pm2) and 0.77 (for $LCPm_1Pm_2$) in males and 0.65 and 0.69, respectively, in females. In order to assess the effect of sex on the regressions, the combined diameters of the canines and premolars were first regressed on combined lower incisor diameters and sex using a general linear model procedure. The p-values associated with sex were found to be less than 0.001 for both arches. Hence, simple linear regressions were performed with sexes separated. All four regression models were statistically significant ($p<0.001$). Residual plots showed fairly even distribution of the residuals above and below zero, and the normal plots of the residuals were fairly straight. Details of the parameters of the regression models are listed in Table 2. Figures 1 to 4 depict the regression line and 95% confidence intervals of the regression line and prediction. The coefficients of determination (R^2) explained the portion of variability of the dependent variable that could be explained by the variability of the independent variable. The R^2 values ranged from 42.5% to 62.6%, with the figures for males consistently better than those for the females. The standard errors of estimate ranged from 0.61 mm to 0.82 mm, with the errors smaller among males. The values of coefficient B were all greater than 0.5 (0.58 to 0.66) and significant at $p<0.001$. The values of coefficient A ranged from 6.66 mm to 8.82 mm. The p-values associated with the coefficient A for males were significant at $p<0.001$. Those for the females were larger, $p=0.005$ for the maxilla, $p=0.011$ for the mandible.

Absolute error of the prediction equations

The absolute error was reached by assessing the differences between observed values of the dependent variable and predicted values from the prediction equation. The distribution of differences was assessed by the Shapiro-Wilk test. Only the distribution of the difference for observed and predicted $LCPm_1Pm_2$ of males showed a marginal tendency to nonnormality ($p=0.047$). Nevertheless, the distributions were assumed to be reasonably normal to warrant the application of parametric tests. The mean errors for each prediction were all zero and are not included in Table 3. Standard deviations and the absolute mean error (mean error without regard to sign) are presented. The percentages of observations having specified mean errors were also tabulated. The absolute mean errors were found to range from 0.601 mm to 0.801 mm. The absolute mean errors for females were consistently larger than those for males in both arches. The percentages of observations having absolute errors greater than 1 mm were smaller among males (6% for the mandibular arch and 11% for the maxillary) than among females (20% for the mandibular arch and 24% for the maxillary).

Probability tables

Probability tables similar to those of Moyers were constructed. Few observations had the combined mesiodistal crown diameters of LI_1I_2 outside the range of 21.0 mm and 26.0 mm. Hence, the probability tables for males (Table 4) and females (Table 5) were constructed for this range of LI_1I_2 values.

Discussion

The tremendous loss of the sample could partly be due to the high mobility of the Hong Kong population. When data from the sample of 5-year-olds was assessed, the sample was found to be representative of the starting sample of 977 in 1986-1988 in terms of age, sex distribution, and sizes of each primary tooth. Hence the studied

Table 4
Probability table for predicting the combined mesiodistal crown diameters (mm) of unilateral canine and premolars from the combined mesiodistal crown diameters (mm) of four mandibular incisors for males

	LI$_1$I$_2$	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00	25.50	26.00
95%	UCPm$_1$Pm$_2$	23.09	23.40	23.71	24.03	24.36	24.69	25.02	25.37	25.71	26.06	26.42
	LCPm$_1$Pm$_2$	22.05	22.34	22.63	22.92	23.21	23.51	23.80	24.10	24.39	24.69	24.99
85%	UCPm$_1$Pm$_2$	22.63	22.95	23.27	23.59	23.92	24.25	24.59	24.93	25.27	25.61	25.96
	LCPm$_1$Pm$_2$	21.67	21.95	22.24	22.54	22.83	23.12	23.41	23.70	24.00	24.29	24.59
75%	UCPm$_1$Pm$_2$	22.37	22.69	23.01	23.34	23.67	24.00	24.33	24.67	25.01	25.35	25.69
	LCPm$_1$Pm$_2$	21.44	21.73	22.02	22.31	22.60	22.89	23.18	23.48	23.77	24.06	24.35
65%	UCPm$_1$Pm$_2$	22.16	22.48	22.81	23.14	23.47	23.80	24.13	24.46	24.80	25.13	25.47
	LCPm$_1$Pm$_2$	21.26	21.55	21.84	22.13	22.42	22.71	23.00	23.29	23.58	23.88	24.17
50%	UCPm$_1$Pm$_2$	21.88	22.21	22.54	22.87	23.20	23.53	23.86	24.19	24.53	24.86	25.19
	LCPm$_1$Pm$_2$	21.02	21.31	21.60	21.89	22.18	22.47	22.76	23.05	23.34	23.63	23.92
35%	UCPm$_1$Pm$_2$	21.60	21.93	22.27	22.60	22.93	23.27	23.60	23.92	24.25	24.58	24.90
	LCPm$_1$Pm$_2$	20.78	21.07	21.36	21.65	21.94	22.23	22.52	22.81	23.10	23.39	23.68
25%	UCPm$_1$Pm$_2$	21.39	21.73	22.04	22.40	22.73	23.05	23.39	23.72	24.04	24.37	24.69
	LCPm$_1$Pm$_2$	20.60	20.89	21.18	21.47	21.76	22.05	22.34	22.63	22.92	23.20	23.49
15%	UCPm$_1$Pm$_2$	21.12	21.47	21.81	22.15	22.48	22.81	23.14	23.46	23.78	24.10	24.42
	LCPm$_1$Pm$_2$	20.37	20.66	20.95	21.24	21.53	21.82	22.11	22.40	22.69	22.97	23.26
5%	UCPm$_1$Pm$_2$	20.67	21.02	21.37	21.71	22.05	22.38	22.70	23.02	23.34	23.65	23.95
	LCPm$_1$Pm$_2$	19.98	20.27	20.57	20.86	21.15	21.43	21.72	22.01	22.29	22.58	22.86

Table 5
Probability table for predicting the combined mesiodistal crown diameters (mm) of unilateral canine and premolars from the combined mesiodistal crown diameters (mm) of four mandibular incisors for females

	LI$_1$I$_2$	21.00	21.50	22.00	22.50	23.00	23.50	24.00	24.50	25.00	25.50	26.00
95%	UCPm$_1$Pm$_2$	22.60	22.90	23.20	23.50	23.81	24.11	24.42	24.73	25.04	25.36	25.67
	LCPm$_1$Pm$_2$	21.54	21.85	22.17	22.49	22.81	23.13	23.45	23.77	24.10	24.42	24.75
85%	UCPm$_1$Pm$_2$	22.07	22.37	22.68	22.98	23.29	23.59	23.90	24.21	24.52	24.83	25.14
	LCPm$_1$Pm$_2$	21.01	21.32	21.64	21.96	22.28	22.60	22.92	23.24	23.57	23.89	24.22
75%	UCPm$_1$Pm$_2$	21.76	22.07	22.37	22.68	22.98	23.29	23.60	23.90	24.21	24.52	24.83
	LCPm$_1$Pm$_2$	20.70	21.01	21.33	21.65	21.97	22.29	22.61	22.93	23.26	23.58	23.90
65%	UCPm$_1$Pm$_2$	21.52	21.82	22.13	22.44	22.74	23.05	23.36	23.66	23.97	24.28	24.59
	LCPm$_1$Pm$_2$	20.45	20.77	21.09	21.41	21.73	22.05	22.37	22.69	23.01	23.34	23.66
50%	UCPm$_1$Pm$_2$	21.20	21.50	21.81	22.12	22.42	22.73	23.04	23.34	23.65	23.96	24.27
	LCPm$_1$Pm$_2$	20.13	20.45	20.77	21.09	21.41	21.73	22.05	22.37	22.69	23.01	23.33
35%	UCPm$_1$Pm$_2$	20.87	21.18	21.49	21.80	22.10	22.41	22.72	23.02	23.33	23.64	23.94
	LCPm$_1$Pm$_2$	19.80	20.12	20.44	20.76	21.08	21.41	21.73	22.05	22.36	22.68	23.00
25%	UCPm$_1$Pm$_2$	20.63	20.94	21.25	21.56	21.86	22.17	22.48	22.78	23.09	23.39	23.70
	LCPm$_1$Pm$_2$	19.55	19.88	20.20	20.52	20.84	21.16	21.48	21.80	22.12	22.44	22.76
15%	UCPm$_1$Pm$_2$	20.32	20.63	20.94	21.25	21.56	21.87	22.17	22.48	22.78	23.09	23.39
	LCPm$_1$Pm$_2$	19.24	19.57	19.89	20.21	20.54	20.86	21.18	21.49	21.81	22.13	22.44
5%	UCPm$_1$Pm$_2$	19.79	20.11	20.42	20.73	21.04	21.34	21.65	21.96	22.26	22.56	22.86
	LCPm$_1$Pm$_2$	18.71	19.04	19.36	19.69	20.01	20.33	20.65	20.97	21.28	21.60	21.91

sample was assumed to be representative of the 12-year-old Hong Kong Chinese children in 1992-1993. Further limitations were imposed on the selection of subjects for simple linear regression analysis. Fifteen subjects were excluded due to the absence of the coexistence of measurable dependent and independent variables. The present study was part of the study for odontometric analysis of primary and permanent crown diameters from serial dental casts of the same individuals and therefore precluded the incorporation of subjects from other sources.

The measurement errors for individual teeth were found to be smaller than or comparable to those reported earlier.[17,23,25,26] When groups of five permanent teeth were assessed, the method error of 0.17 mm was also found to be smaller than the error found by other researchers.[23,27] The use of calipers with digital display might have greatly reduced eye fatigue and the possibility

Table 6
Pearson's product-moment correlation coefficients for different ethnic groups

Study	Ethnic group	$UCPm_1Pm_2:LI_1I_2$ M	$UCPm_1Pm_2:LI_1I_2$ F	$LCPm_1Pm_2:LI_1I_2$ M	$LCPm_1Pm_2:LI_1I_2$ F
Ballard, Wylie, 1947	Caucasian			0.64	
Hixon, Oldfather, 1958	Caucasian			0.69	
Bolton, 1958	Caucasian			0.65	
Moorrees, Reed, 1964	Caucasian	0.51		0.58	
Tanaka, Johnston, 1974	Caucasian	0.625		0.648	
Smith, King, Valencia, 1979	Caucasian			0.66	
Ferguson et al., 1978	American black	0.630		0.706	
Frankel, Benz 1986	American black	0.72	0.61	0.79	0.66
Zilberman et al., 1977	Israeli	0.64		0.66	
Present study	Hong Kong Chinese	0.79	0.65	0.77	0.69

of reading error.

Prior study of mesodistal crown diameters revealed that bilateral asymmetry was statistically significant at 5% in four primary teeth and one permanent tooth in both sexes. When the amount of asymmetry was expressed in terms of percentage of the standard deviations of the corresponding tooth size, it ranged from 5% to 12%. This finding agreed with prior reports and averaging the crown diameters of antimeres was justified.

The combined mesiodistal crown diameters of the canine-premolar segments were statistically larger in males, and the mandibular incisor segment was larger in females, although the difference was not significant (Table1). The combined crown diameters of these tooth segments in Hong Kong Chinese were found to be comparable to or smaller than those of the Australian aboriginals[28] but larger than those of the American whites.[29]

The correlation coefficients between the combined crown diameters of the canine-premolar and lower incisor segments for Hong Kong Chinese were found to be 0.79 ($UCPm_1Pm_2$ with LI_1I_2) and 0.77 ($LCPm_1Pm_2$ with LI_1I_2) for males, and 0.65 and 0.69, respectively, for females. These figures were among the highest of published data (Table 6). Moorrees and Reed[31] reported figures of 0.51 ($UCPm_1Pm_2$ with LI_1I_2) and 0.58 ($LCPm_1Pm_2$ with LI_1I_2). Other studies of Caucasians[3,7,8,10,30,31] reported higher values for both arches (r=0.63 to 0.69), while Israeli children[27] were found to have comparable coefficients. Coefficients were higher for American blacks[18,20] than for whites, but smaller than for Hong Kong Chinese, except for the coefficient between $LCPm_1Pm_2$ with LI_1I_2 in males.

The slope of the simple linear regression is the parameter of interest that indicates the strength of the relationship between the dependent and independent variables of the regression equation. The present study found coefficients for the slope ranged from 0.58 to 0.66 (Table 2). These values were larger than those found for Caucasians[7,8,11] and larger than or comparable to those found for American blacks[18,20] and Saudi Arabians.[19] The R^2 values were found to be higher in both arches for males than for females.

Using the values of coefficients A and B listed in Table 2, four equations for the prediction of upper and lower combined canine-premolar crown diameters in each sex were derived as follows:

Male $UCPm_1Pm_2$: $Y = 7.97 + 0.66X$
Male $LCPm_1Pm_2$: $Y = 8.22 + 0.58X$
Female $UCPm_1Pm_2$: $Y = 8.30 + 0.61X$
Female $LCPm_1Pm_2$: $Y = 6.66 + 0.64X$

These equations can predict the value of Y at the 50th percentile of the probability table.

The standard error of estimate (SEE) expresses the error involved in the use of the prediction equations. The regression line gives a mean predicted size of canine-premolars for a given size of LI_1I_2. About 68% of the patients will have a true sum of canine and premolar widths in the range of the values from 1 SEE below to 1 SEE above the mean predicted size. The SEE for Hong Kong Chinese was found to range from 0.61 mm to 0.82 mm, which was comparable to errors reported in the literature.[4,7,11,18] The figures for males were consistently smaller than for females. The absolute error is the assessment of the differences between predicted and observed values without regarding the signs of the differences.

The present study found that the absolute mean error ranged from 0.67 to 0.80 mm, similar to other studies.[8,10,12] The percentage of observations with absolute error greater than 1 mm was lower for males (11% for $UCPm_1Pm_2$, 6% for $LCpm_1Pm_2$) than females (24% for $UCPm_1Pm_2$, 20% for $LCPm_1Pm_2$), which could be explained by the lower correlation coefficient between the crown diameters of the canine-premolars and lower incisors in females. These findings were better than those found in Japanese subjects[9] when the Moyers' probability tables and Ballard and Wylie's[8] prediction equation were applied. The percentages of observations with absolute error greater than 1 mm were 30% and 25%, respectively, for the two methods. In the present study, the values of R^2, standard error of estimate, and absolute error all pointed to the fact that the prediction models for females were less precise than for males. Similar findings have been observed by other authors.[13,18]

A value of 0.5 for the coefficient of the regression equation facilitates practical application of the prediction equations because half of the lower incisor diameters can be computed easily or measurements can be made on two incisors (one central and one lateral) only. This may be one of the reasons for the wide-spread application of Tanaka and Johnston's prediction equations. However, different values for B have been found for non-Caucasian samples.[18-20] The present study also yielded values for B that were close to and above 0.6. The Prince Philip Dental Hospital presently uses prediction equations modified from those of Tanaka and Johnston, in addition to Moyers' probability tables. Due to differences in the value of B, the modified Tanaka and Johnston predictions would tend to over-predict the width of the canine-premolar segments at the smaller end and under-predict at the larger end of the range of LI_1I_2 values. This trend would also be reflected by fitting the predicted values from the modified equations into the probability tables.

For the local Chinese population, the sizes of unerupted canine and premolars can be predicted using the probability tables derived from local populations (Tables 4 and 5). This method is equally convenient and no memorization of equations is necessary. Frankel and Benz[18] did provide probability tables derived from American blacks for predicting the canine-premolar sizes in American blacks. For Caucasian populations, the 75th percentile of Moyers' probability tables is the most widely used prediction level. Tanaka and Johnston's prediction equations also fell into that percentile. The over-prediction at that level may offer extra protection, which is needed more in the case of crowding than of spacing.[11] The experienced clinician may choose to use the 50th percentile level[11] because it is a more precise estimate and the error would distribute equally on both sides. Nevertheless, some authors recommend under-prediction because it results in a more conservative clinical approach and unnecessary extractions may be avoided.[17] Hence, the choice of percentile levels of the probability table to be used may vary from clinician to clinician.

The precision of the prediction equations is currently being tested in the local population using a larger sample. As Ballard and Wyelie[8] had advocated, the prediction method should not be adopted as a superscientific method of arriving mysteriously at the precise diameter of the unerupted canines and premolars. The errors involved in measurement and prediction equations should be recognized.

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