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Tanaka–Johnston Mixed Dentition Analysis for Southern Chinese in Hong Kong

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ABSTRACT

Objective: To compare the prediction of unerupted permanent canine and premolar size of a comparable sample size of southern Chinese population with that of the study of Tanaka and Johnston.

Materials and Methods: Teeth on study casts of an unselected sample from a 12-year-old Hong Kong Oral Health Survey of 12-year-old children (n = 459; 295 males and 164 females) were measured in the mesiodistal dimension. A Chinese mixed dentition analysis based on the Tanaka and Johnston method was constructed with linear regression equations for prediction of the mesiodistal widths of unerupted canines and premolars.

Results: Sexual dimorphism was evident between southern Chinese males and females in incisors, canines, and premolars in the mesiodistal dimension.

Conclusions: To predict the space (in mm) required for alignment of unerupted canine and premolars in southern Chinese children, halve the sum of the mesiodistal dimensions of the four mandibular incisors and add the respective constants for males (upper, 11.5; lower, 10.5) or females (upper, 11.0; lower, 10.0).

KEY WORDS: Mixed dentition analysis, Southern Chinese, Space analysis.

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INTRODUCTION Return to TOC

The prediction of unerupted permanent canine and premolar size in patients in the mixed dentition is important in early orthodontic diagnosis and treatment.[1] Accurate estimation of the sizes of canines and premolars allows the dentist to better manage tooth/arch length discrepancies.

Tanaka and Johnston[1] calculated linear regression equations for the prediction of the mesiodistal widths of unerupted canines and premolars for a sample of 506 North American orthodontic patients. Since then, their method of prediction has been widely used. Race-specific predictive data are needed for different parts of the world. The Chinese (Mongoloid) race comprises a quarter of the world's population, but little research has been carried out on Chinese dentition. The Mongoloid dental complex exhibits a combination of diagnostic features that clearly distinguish it from others.[2]

" Southern Chinese" are defined as those Chinese whose ancestors originated from provinces south of the Yangtze River and who speak different dialects from the northerners. Ling[2] demonstrated that the southern Chinese showed larger tooth dimensions than Caucasians. Sexual dimorphism was evident in all tooth types in nearly all tooth dimensions, with the exception of the mesiodistal dimension between male and female mandibular central incisors. Yuen et al[3] attempted to construct prediction equations for canines and premolars on the basis of lower incisors from 97 Hong Kong Chinese. Ta et al[4] showed that the Bolton standards were applicable to southern Chinese children with Class I occlusion but not to those with Class II or Class III occlusions. Therefore, they noted that specific standards should be used for the southern Chinese.

Quite a number of these southern Chinese immigrated to different parts of the world in the 1980s and 1990s, especially to the western countries. Therefore, an investigation of the regression equations for the prediction of unerupted permanent canine and premolar size of the southern Chinese population of a comparable sample size with that of the study of Tanaka and Johnston is not only important locally but also has worldwide significance.

MATERIALS AND METHODS Return to TOC

Dental study casts (n = 459; 295 males and 164 females) were obtained as part of a multidisciplinary survey of a cross-sectional, randomly selected sample of one thousand two hundred and forty seven 12-year-old Chinese children from the Oral Health Project in Hong Kong.[2,5] Teeth found to be carious, missing, restored at the measurement landmark, hypoplastic, worn, or malformed were excluded from the present investigation. The sample included different types of occlusion in permanent dentition.

Damaged casts, which made the measurement data questionable, were also omitted. A sliding dial caliper (Mitutoyo Manufacturing Co. Ltd, Tokyo, Japan) accurate to within ±0.02 mm was used to carry out all manual measurements. The beaks of the caliper were machine-sharpened to a fine taper to improve accessibility to the proximal surface of teeth, especially for the mesiodistal dimension. All manual measurements were recorded to the nearest 0.01 mm after initial calibration with another orthodontist. All manual measurements were made and recorded by co-author Dr Ling.

Mesiodistal crown dimension of all erupted permanent incisors, canines, and premolars was measured with the sliding caliper according to the method described by Moorrees et al.[6] The maximum distance of the tooth crown between the contact points on its proximal surfaces was measured parallel to the occlusal and labial surfaces. Otherwise, the mesiodistal crown dimension was obtained by measuring between the points where contact with the neighboring teeth "normally" should occur. When the measurement landmark was obstructed, or the beaks of the caliper could not reach it, such data were excluded, eg, for partially erupted, rotated, or impacted teeth. This method was adopted because it is the most widely used and has the greatest value for comparative analyses.[2]

It seemed prudent to measure all the available study casts; hence, a pilot study was carried out to estimate the population variance. The average calculated sample size (n = 459) lies between 75 and 100 for each tooth pair when a 95% confidence level ($\alpha = 0.05$) and a precision of ±0.1 mm in estimation were used.[2]

RESULTS Return to TOC

The mesiodistal permanent incisors, canines, and premolars of 12-year-old southern Chinese are shown in Table 1. Males had larger absolute mesiodistal tooth dimensions in all tooth types in both arches. The absolute size difference ranged from the smallest intersex difference of 0.05 mm of the mandibular central incisor to the greatest intersex difference of 0.42 mm of the mandibular canines. All the teeth were significantly different (*t*-test, $P \leq .05$) between the sexes, with the exception of lower lateral incisors, which were not statistically different. The standard deviations and coefficients of the variation given in Table 1 show that mesiodistal tooth dimension differed between tooth types.

Computation of the prediction formulas

The foundation of this mixed dentition analysis was based on the moderate correlations between the sums of the mandibular incisors and the sums of canine-premolar in both arches. Linear regression equations such as the least squares regression equation of the form $y = A + B(x)$ were calculated. In these equations, y equals the predicted size of the unerupted canines and premolars, x equals the measured combined mesiodistal dimensions of the four lower incisors, and A and B are constants. B was suggested to be half.[1] To analyze the mixed dentition analysis, the following mesiodistal dimensions were summed and computed:

$$\text{Sum } 1 = \text{m.d. } 12 + \text{m.d. } 11 + \text{m.d. } 21 + \text{m.d. } 22$$

$$\text{Sum } 2 = \text{m.d. } 31 + \text{m.d. } 41 + \text{m.d. } 32 + \text{m.d. } 42$$

$$\text{Sum } 3 = \text{m.d. } 13 + \text{m.d. } 14 + \text{m.d. } 15$$

$$\text{Sum } 4 = \text{m.d. } 23 + \text{m.d. } 24 + \text{m.d. } 25$$

$$\text{Sum } 5 = \text{m.d. } 35 + \text{m.d. } 34 + \text{m.d. } 35$$

$$\text{Sum } 6 = \text{m.d. } 43 + \text{m.d. } 44 + \text{m.d. } 45$$

$$\text{If (Sum } 3 > 0) \quad \text{Sum } 7 = \text{Sum } 3$$

$$\text{If (Sum } 4 > 0) \quad \text{Sum } 7 = \text{Sum } 4$$

$$\text{If (Sum } 3 > 0 \text{ and Sum } 4 > 0), \quad \text{Sum } 7 = 0.5 \times (\text{Sum } 3 + \text{Sum } 4)$$

$$\text{If (Sum } 5 > 0) \quad \text{Sum } 8 = \text{Sum } 5$$

$$\text{If (Sum } 6 > 0) \quad \text{Sum } 8 = \text{Sum } 6$$

$$\text{If (Sum } 5 > 0 \text{ and Sum } 6 > 0), \quad \text{Sum } 8 = 0.5 \times (\text{Sum } 5 + \text{Sum } 6)$$

$$x = \text{Sum } 7 - 0.5 \text{ Sum } 2$$

$$y = \text{Sum } 8 - 0.5 \text{ Sum } 2$$

The results of the means, standard deviations, standard error of the means, and correlation coefficients of the above equations are shown in Tables 2 and 3.

The method error, which represents the uncertainty of the individual observation of a variable, was determined using duplicate measurements of all the variables. It was considered unnecessary to take an extra alginate impression for dental study cast to account for the variance because of dimensional changes in the impression material and dental stone. This variance was considered to be very small compared with that due to the error of measurement.[7] In addition, in clinical practice, dentists use the study casts rather than the teeth in the mouth for performing mixed dentition analysis.

The study casts of the participants from the first school were used in the pilot study. Eighteen randomly selected study casts taken from the study were measured and analyzed on two different occasions at an interval of at least 3 months. The error for the method was calculated for all parameters using the double determination method.[8] The method error for manual measurements of tooth dimensions was within 0.1 mm. The magnitude of this error was similar to those of the previous studies.[6,7]

The calculated constants for the southern Chinese were as follows:

$$\text{Male Upper constant, } A_{mu} = 11.5 \text{ mm}$$

$$\text{Male Lower constant, } A_{ml} = 10.61 \text{ mm}$$

$$\text{Female Upper constant, } A_{fu} = 10.86 \text{ mm}$$

$$\text{Female Lower constant, } A_{fl} = 9.85 \text{ mm}$$

Prediction of space required for alignment of unerupted canine and premolars

This prediction was carried out using the following procedure:

1. Halve the sum of mesiodistal dimensions of the four mandibular incisors.

2. To this derived size, add the respective constants for male and female in the two arches.

For simplicity and easy memorization when performing mixed dentition analysis, the constants for male and female southern Chinese are approximated, and these approximated constants are shown in Table 4. The original Tanaka and Johnston constants for Americans are also shown in Table 4 for comparison.

DISCUSSION Return to TOC

Prediction of the mesiodistal dimensions of unerupted permanent canines and premolars during the mixed dentition is of clinical importance in diagnosis and planning treatment. Accurate estimation of the size of the canines and premolars allows the dentist to better manage tooth size/arch length discrepancies. However, great care must be taken to avoid letting numbers dictate the prediction of tooth size because dental arch perimeter may change with time. In addition, it is obvious that the best predictor tooth is the erupted antimere in the same patient, and the best estimate is from radiographs.

The relation of upper centrals with canines and premolars showed a significant positive moderate correlation. These positive correlations in a series of teeth should, within certain limits, fairly accurately allow the calculation and prediction of the size of unknown components, eg, unerupted or ectopically displaced teeth. This has been the basis for analyses known as mixed dentition analyses.[1,9,10]

Sexual dimorphism in the mesiodistal dimension was evident between southern Chinese males and females in incisors, canines, and premolars. The largest percentage of sexual dimorphism [(male/female) − 1 × 100%] of the mesiodistal dimension in southern Chinese was the mandibular canine (6.1%) followed by the maxillary canine (4.7%). The least percentage of sexual dimorphism was lower centrals. Therefore, separate prediction equations are needed for males and females.

This young age group was chosen for measurement to minimize the alteration of the mesiodistal tooth dimensions because of attrition, restoration, or caries. Efforts were made to ensure randomization, and adequate sample size was used to ensure validity and adequate clinical significance of the prediction equations.

CONCLUSIONS Return to TOC

- To predict the space (in mm) required for alignment of unerupted canine and premolars in southern Chinese children, halve the sum of mesiodistal dimensions of the four mandibular incisors and add the respective constants for males (upper, 11.5; lower, 10.5) or females (upper, 11.0; lower, 10.0).

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TABLE 1. Mesiodistal Tooth Dimension of 12-y-old Southern Chinese Males and Females Manual Measurements (mm)

	Sex	n[a]	Mean	SE	SD	CV[b] %	Sexual Dimorphism d[c]	%[d]	Rank[e]
Maxillary Arch									
Central incisor	♂	260	8.85	.033	.53	6.0	.16	1.84	8
	♀	144	8.69	.039	.47	5.4			
Lateral incisor	♂	258	7.36	.037	.59	8.0	.18	2.51	5
	♀	150	7.18	.050	.61	8.5			
Canine	♂	181	8.30	.035	.47	5.7	.38	4.80	2
	♀	129	7.92	.032	.37	4.7			
First premolar	♂	233	7.77	.028	.42	5.4	.20	2.51	5
	♀	137	7.57	.030	.35	4.6			
Second premolar	♂	198	7.26	.026	.36	5.0	.16	2.25	7
	♀	116	7.10	.032	.34	4.8			
Mandibular Arch									
Central incisor	♂	264	5.62	.021	.34	6.1	.05	.90	10
	♀	148	5.57	.027	.33	5.9			
Lateral incisor	♂	261	6.22	.025	.41	6.6	.08	1.30	9
	♀	140	6.14	.027	.31	5.1			
Canine	♂	228	7.31	.028	.42	5.7	.42	6.10	1
	♀	146	6.89	.028	.34	4.9			
First premolar	♂	227	7.58	.028	.42	5.5	.22	2.99	3
	♀	139	7.36	.029	.34	4.6			
Second premolar	♂	198	7.56	.029	.41	5.4	.21	2.86	4
	♀	118	7.35	.034	.37	5.0			

[a] n = Number of cases, left and right sides pooled
[b] CV = Coefficient of variation = (SD ÷ mean) × 100%.
[c] d (difference) = Male m.d. − Female m.d.
[d] Percentage sexual dimorphism = (Male m.d. ÷ Female m.d.) − 1 × 100%.
[e] Rank is the ranking of percentage sexual dimorphism form highest (1) to lowest (10).

TABLE 2. Means, Standard Variations, and Standard Error of the Means of Sums of Teeth (mm)

	Male				Female			
	n[a]	Mean	SE	SD	n	Mean	SE	SD
Sum 1	251	32.44	0.13	2.04	143	31.73	0.16	1.93
Sum 2	257	23.69	0.09	1.40	139	23.43	0.10	1.20
Sum 3	177	23.33	0.08	1.04	114	22.59	0.08	0.89
Sum 4	170	23.33	0.09	1.13	112	22.57	0.09	0.95
Sum 5	200	22.41	0.08	1.15	123	21.61	0.08	0.94
Sum 6	187	22.47	0.08	1.12	125	21.56	0.08	0.89
Sum 7	192	23.37	0.08	1.09	122	22.60	0.08	0.89
Sum 8	209	22.45	0.08	1.12	132	21.56	0.08	0.89
x	183	11.48	0.06	0.78	113	10.86	0.07	0.73
y	199	10.61	0.06	0.81	123	9.85	0.06	0.68

[a] n = number of cases.

TABLE 3. Pearson Product Moment Correlation Coefficient for Summated Mesiodistal Dimensions and Maxillary (x) and Mandibular constants (y)[a,b]

Sum	1	2	3	4	5	6	7	8	x	y
1		0.82 (239)	0.66 (167)	0.70 (161)	0.71 (187)	0.69 (174)	0.71 (182)	0.70 (194)	0.29 (176)	0.27 (187)
2	0.73 (132)		0.66 (168)	0.70 (161)	0.70 (192)	0.72 (178)	0.70 (183)	0.71 (199)	0.09[NS] (183)	0.13* (199)
3	0.64 (111)	0.59 (107)		0.94 (155)	0.84 (159)	0.86 (160)	0.98 (177)	0.87 (166)	0.74 (168)	0.64 (160)
4	0.68 (108)	0.59 (104)	0.94 (104)		0.85 (153)	0.87 (150)	0.98 (170)	0.87 (158)	0.78 (161)	0.64 (152)
5	0.64 (117)	0.62 (115)	0.86 (103)	0.85 (102)		0.94 (178)	0.86 (172)	0.99 (200)	0.60 (167)	0.78 (192)
6	0.72 (120)	0.67 (117)	0.87 (106)	0.86 (103)	0.90 (110)		0.88 (169)	0.98 (187)	0.60 (163)	0.77 (178)
7	0.67 (117)	0.60 (113)	0.99 (114)	0.99 (112)	0.86 (112)	0.87 (112)		0.89 (179)	0.77 (183)	0.64 (173)
8	0.70 (126)	0.66 (123)	0.89 (109)	0.88 (108)	0.98 (123)	0.98 (125)	0.88 (117)		0.62 (173)	0.79 (199)
x	0.261* (108)	−0.06[NS] (113)	0.76 (107)	0.77 (104)	0.57 (104)	0.57 (105)	0.76 (113)	0.58 (109)		0.77 (173)
y	(118)	(123)	0.30 (103)	−0.01[NS] (101)	0.74 (115)	0.74 (117)	0.66 (109)	0.45 (105)		

* $P \leq .05$.

[a] NS indicates not significant.

[b] All correlations were significant at $P \leq .001$ except where indicated by NS and *.

TABLE 4. Tanaka and Johnston Constants for Chinese and Amer icans

	Male (Southern Chinese)	Female (Southern Chinese)	Tanaka and Johnston (Americans)
Maxillary arch	11.5	11.0	11.0
Mandibular arch	10.5	10.0	10.5

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