The prediction of the tooth size in the mixed dentition for Korean

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Abstract

Estimating the size of unerupted teeth is an essential aspect of orthodontic diagnosis and treatment planning in the mixed dentition.

Several methods were introduced and used for the prediction. The most common methods among these would be Moyers probability chart and Tanaka and Johnston equations. These are currently used widely, but they were developed for Caucasians.

Because there are clear racial differences in teeth size, the objectives of this study were to produce correlation coefficients between the combined mesiodistal widths of the permanent mandibular incisors and those of the canines and premolars for each quadrant, and prediction tables with regression equations, specifically for Korean. 178 young adults (70 women, 108 men, mean age 21.63 years) were selected from the College of Dentistry, Yonsei University, Seoul, Korea. The mesiodistal crown diameters of the permanent teeth were measured with calipers. Significant sexual dimorphism was found in tooth sizes. The correlation coefficients between the total mesiodistal width of the mandibular permanent incisors and those of the maxillary and mandibular canines and premolars were found to be between 0.52 and 0.64. The standard error of the estimatation was better (0.60) for women and the r^2 values ranged from 0.27 to 0.41 for both sexes. Prediction tables were prepared for Korean.

This study showed larger canine and premolar diameters than Tanaka and Johnston's and Moyers' studies which might be due to the racial differences.

Further investigations with a larger sample size will be needed for more representative data on the Korean population.

Key words : Mixed dentition analysis, Tooth size, Prediction tables

I. INTRODUCTION

In orthodontic diagnosis of mixed dentition, space analysis is very important in predicting the mesiodistal crown diameters of the permanent canines and premolars and an essential diagnostic procedure[1-3].

The purpose of space analysis is to allow the eruption of the permanent successors and to evaluate the required space for occlusal adjustment. In order to perform this procedure, a prediction of mesiodistal widths of unerupted permanent canines and premolars is needed.

Three methods of prediction are widely used: direct measurements of unerupted tooth sizes on radi-

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ographs[3,5]; calculations from prediction equations and tables[1,4,6] ; and a combination of radiographic measurements and prediction tables[3,7,8].

Among these, the combination of radiographic measurements and prediction tables proposed by Hixon and Oldfather[7] is believed to be the most accurate[9,10]. However it is complex, and sometimes difficult to use. So the regression equations based on the already erupted permanent teeth in early mixed dentition are the most broadly used, especially the Moyers probability table and the Tanaka and Jhonston equation.

Recently, there are some mentions that the sum of mesiodistal diameter of lower incisor used in the Moyers[1] and the Tanaka and Johnston's method[4] is not the best predictor for unerupted canine and premolar sums[11-13]. But the Tanaka and Johnston prediction equations and the Moyers probability table are still widely used in Korean dental clinic.

Because there are definite racial differences with respect to the tooth sizes[14,15], the application of the Moyers probability table and the Tanaka and Johnston equation which were developed for Caucasians, to the local Korean population may have undermined the accuracy of these predictions[16]. So it is reasonable to question if it can be used in Korean.

The aims of this study were (1) to obtain the correlation coefficients between the combined mesiodistal widths of the permanent mandibular incisors and those of the canines and the first and second premolars of maxillary or mandibular quadrant, (2) to test the reliability of both the Moyers and the Tanaka and Johnston methods in a Korean group, and (3) to construct probability tables for Korean children based on the Moyers and the Tanaka and Johnston methods.

Ⅱ. MATERIAL AND METHODS

420 students from the College of Dentistry, Yonsei University, Seoul, Korea were examined and 178 young adults (108 males, 70 females, mean age 21.63 years) were selected. In this study the dental casts from 178 Korean young adults with a normal occlusion were used.

All the selected samples were native Korean and the selection criteria were (1) no congenital craniofacial anomalies or previous history of orthodontic treatment, (2) all permanent teeth present in each arch with the exception of the third molars, (3) an intact dentition with no proximal caries, restorations, or significant attritions, (4) Angle Class I molar relationship, (5) no more than mild crowding or spacing.

The data was obtained from the direct measuring of dental casts. The mesiodistal diameter of all mandibular and maxillary canines, premolars and mandibular incisors were measured by a single investigator using the measuring method proposed by previous studies[17-19].

The inter-examiner reliability was tested (Cronbach, alpha=0.83). The intra-examiner reliability was predetermined at 0.2 mm, as suggested by Bishara et al.[8] The 2 sets of measurements were compared. The measurements were averaged when they varied by 0.2 mm or less.

Statistical datas, such as the means, standard deviations, and minimum and maximum values were calculated. Student t tests were used to compare the tooth sizes between genders. The correlation coefficients (r) and regression equations ($y = a + bx$) were formulated in order to evaluate the relationships between the combined widths of the 4 mandibular incisors (x) and those of the canine and premolars (y) on each dental arch.

The constants a and b in the standard linear regression equation ($y = a + bx$), the coefficients of determination (r^2), and the standard errors of the estimates (SEE) were calculated for men and women separately. The r^2 value is an indicator of predictive accuracy of the regression equation. The SEE indicates the error involved in the use of the prediction equations.

These equations were also used to assess the differences using the Tanaka and Johnston[4] method and Moyers probability charts[1] (75%).

Probability tables for the Korean children were constructed. Statistical analysis was performed using statistical software (SAS, ver 8.1).

Ⅲ. RESULTS

The descriptive statistics for the summation of the upper canine and premolar diameters (UCPM), the summation of the lower canine and premolar diame-

Table 1. Descriptive statistics for the UCPM, LCPM, and LI

Tooth group	Sex	N	Mean (mm)	Range (mm)	SD (mm)
LI	M	108	23.29	21.28-26.24	1.16
UCPM	M	108	23.20	20.06-26.66	1.02
LCPM	M	108	22.28	20.26-25.50	0.94
LI	F	70	22.88	19.69-27.17	1.29
UCPM	F	70	22.47	19.71-25.23	1.02
LCPM	F	70	21.54	19.08-24.10	1.02

The mesiodistal diameters of canine-premolar segments in both arches were statistically larger in men than in women ($p < 0.05$).
SD, standard deviation; *M*, male; *F*, female;
UCPM, summation of the upper canine and premolar diameters;
LCPM, summation of the lower canine and premolar diameters;
LI, summation of the lower incisor mesiodistal diameters.

Table 2. Regression parameters for predicting the buccal segment widths

Tooth group	sex	*R*	A	b	SEE(mm)	r^2
UCPM	M	0.57	11.20	0.51	0.80	0.33
LCPM	M	0.64	10.01	0.53	0.70	0.41
UCPM	F	0.52	12.90	0.42	0.60	0.27
LCPM	F	0.58	10.89	0.47	0.60	0.34

M, Male; *F*, female; *r*, correlation coefficient; r^2 coefficients of determination
SEE, standard errors of the estimates;
UCPM, summation of the upper canine and premolar diameters;
LCPM, summation of the lower canine and premolar diameters

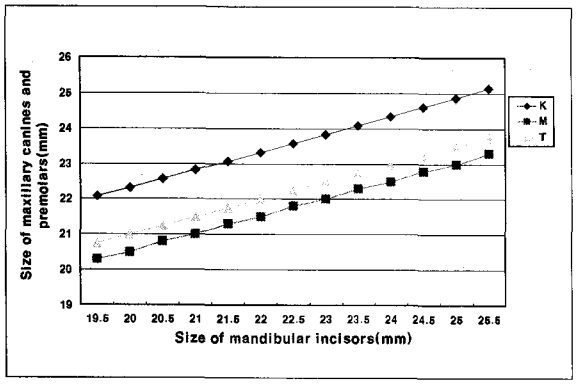

Fig. 1. Comparison of predicted values of unerupted maxillary canines and premolars(male) (K : new Korean prediction equations, M : Moyers charts (75%), T : Tanaka and Johnston equations)
Tanaka and Johnston equations and the Moyers chart (75%) underestimated the size of the canines and premolars in the maxilla for Korean males.

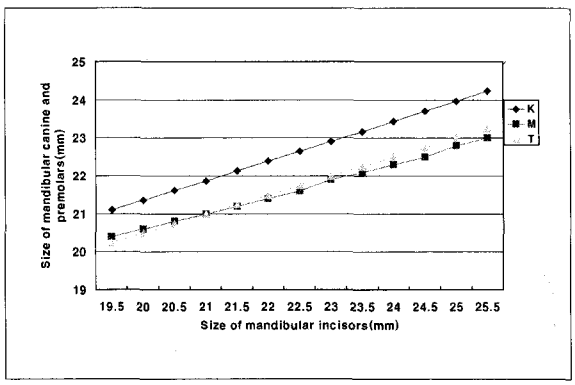

Fig. 2. Comparison of predicted values of unerupted mandibular canines and premolars(male) (K : new Korean prediction equations, M : Moyers charts (75%), T : Tanaka and Johnston equations)
Tanaka and Johnston equations and the Moyers chart (75%) underestimated the size of the canines and premolars in the mandible for Korean males.

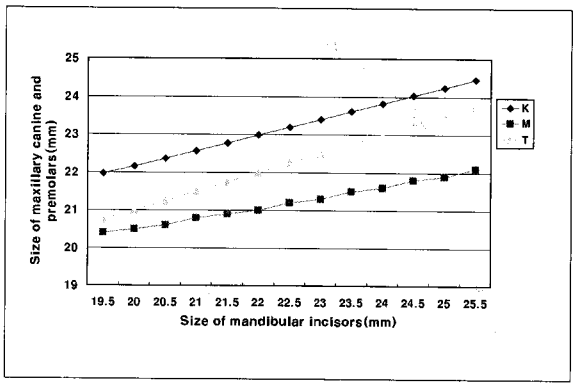

Fig. 3. Comparison of predicted values of unerupted maxillary canines and premolars(female) (K : new Korean prediction equations, M : Moyers charts (75%), T : Tanaka and Johnston equations)
The data for females shows similar pattern to the result for Korean males in maxilla.

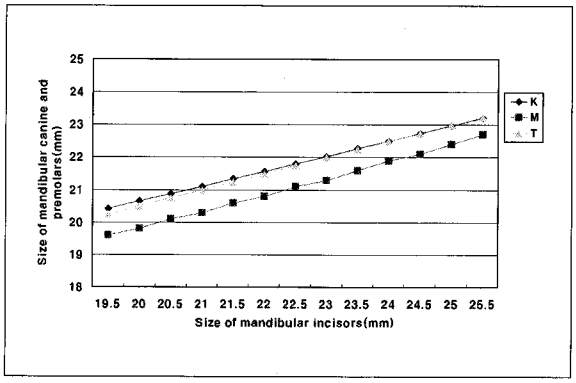

Fig. 4. Comparison of predicted values of unerupted mandibular canines and premolars(female) (K : new Korean prediction equations, M : Moyers charts (75%), T : Tanaka and Johnston equations)
In mandible, the Tanaka and Johnston equation was similar to our data for Korean female.

Table 3. Prediction table for Korean males (mm)

LI	75%		50%		25%	
	UCPM	LCPM	UCPM	LCPM	UCPM	LCPM
19.5	22.08	21.11	21.24	20.28	20.41	19.44
20.0	22.32	21.36	21.50	20.54	20.68	19.72
20.5	22.57	21.62	21.76	20.80	20.94	19.99
21.0	22.82	21.87	22.02	21.07	21.21	20.26
21.5	23.07	22.13	22.27	21.33	21.47	20.53
22.0	23.32	22.39	22.53	21.59	21.74	20.80
22.5	23.58	22.65	22.79	21.86	22.00	21.07
23.0	23.83	22.91	23.05	22.12	22.26	21.33
23.5	24.09	23.17	23.30	22.39	22.52	21.60
24.0	24.35	23.44	23.56	22.65	22.77	21.86
24.5	24.61	23.71	23.82	22.91	23.03	22.12
25.0	24.87	23.97	24.08	23.18	23.28	22.38
25.5	24.87	24.24	24.33	23.44	23.53	22.64
26.0	25.14	24.52	24.59	23.70	23.78	22.89
26.5	25.40	24.79	24.85	23.97	24.03	23.14
27.0	25.67	25.07	25.11	24.23	24.27	23.40

UCPM, summation of the upper canine and premolar diameters;
LCPM, summation of the lower canine and premolar diameters;
LI, summation of the lower incisor mesiodistal diameters

ters (LCPM), and the summation of the lower incisor mesiodistal diameters (LI) are presented in Table 1. for men and women separately.

The mesiodistal diameters of canine-premolar segments in both arches were statistically larger in men than in women ($p<0.05$).

From the collected data, the correlation coefficients and prediction equations were derived. The correlation coefficients (r) between the LI and buccal segments for men and women, the regression values of a and b in the standard linear regression equation ($y = a + bx$), SEE, and r^2 of the maxillary and mandibular regression equations are presented in the Table 2.

Table 4. Prediction table for Korean females (mm)

LI	75%		50%		25%	
	UCPM	LCPM	UCPM	LCPM	UCPM	LCPM
19.5	21.96	20.43	21.06	19.53	20.15	18.63
20.0	22.16	20.66	21.26	19.76	20.37	18.87
20.5	22.36	20.88	21.47	19.99	20.59	19.11
21.0	22.57	21.11	21.68	20.23	20.80	19.34
21.5	22.77	21.34	21.89	20.46	21.01	19.58
22.0	22.98	21.57	22.10	20.69	21.22	19.81
22.5	23.19	21.80	22.31	20.92	21.43	20.05
23.0	23.40	22.03	22.52	21.16	21.64	20.28
23.5	23.61	22.27	22.73	21.39	21.85	20.51
24.0	23.82	22.50	22.94	21.62	22.06	20.74
24.5	24.03	22.74	23.15	21.85	22.27	20.97
25.0	24.24	22.97	23.36	22.09	22.47	21.20
25.5	24.46	23.21	23.57	22.32	22.68	21.43
26.0	24.67	23.45	23.78	22.56	22.88	21.65
26.5	24.89	23.69	23.98	22.78	23.08	21.88
27.0	25.11	23.93	24.19	23.02	23.28	22.10

UCPM, summation of the upper canine and premolar diameters;
LCPM, summation of the lower canine and premolar diameters;
LI, summation of the lower incisor mesiodistal diameters

The correlation coefficients were from 0.52 to 0.64 with the coefficients being higher in men. The r^2 values ranged from 27% in women to 41% in men, and the SEE was better (0.60 mm) for women.

Fig. 1, Fig. 2, Fig. 3 and Fig. 4 represents the relative comparisons between the predicted values at the 75th percentile level by the proposed equations in Korean, Tanaka and Johnston equations[4] and Moyers probability charts[1] at the 75th percentile level for maxillary and mandibular buccal segments.

Graphically, the Tanaka and Johnston equations[4] and the Moyers chart[1] (75%) underestimated the size of the canines and premolars in the maxilla and mandible for Korean males (Fig. 1, 2). The data for females shows somewhat different results. For the maxilla, it is similar to the result for males (Fig. 3). However, in the mandible, the Tanaka and Johnston equation[4] was similar to our data (Fig. 4).

Table 3 and Table 4 shows the newly proposed prediction tables determined from the regression equations of this study.

Ⅳ. DISCUSSION

Although there are many methods in diagnostic phase of orthodontic treatment, dental casts are still believed to be a vital diagnostic tool[20]. From the dental cast, one can analyze the tooth size and the shape of the tooth, evaluating the alignment and rotations of the teeth, the presence or absence of teeth, the arch form and symmetry, the arch width and the occlusal relationship.

As many other biological forms, the teeth are present in different sizes and shapes. Variations in the size and shape of the teeth are mostly genetically determined[21,22]. The genetic basis for this variation is best explained by the polygenic model of inheritance. Lundström[23] compared 97 pairs of monozygotic and dizygotic twins, and found a strong correlation in the mesiodistal tooth size between the monozygotic twins. He concluded that the tooth size is determined by genetic factors to a large extent.

Several methods were introduced and used to predict the sizes of unerupted teeth. The most common method among these is Moyers analysis[1]. Moyer es-

Table 5. Regression parameters for the buccal segment widths of Asian from various investigations

Study	sex	Arch(y)	r	Constants		SEE(mm)	r^2
				a	b		
Jaroontham et al(2000) (Thai)	M	Mx	0.54	13.36	0.41	0.88	0.29
		Mn	0.58	11.92	0.43	0.85	0.34
	F	Mx	0.62	11.16	0.49	0.78	0.39
		Mn	0.65	9.49	0.53	0.78	0.42
Yuen et al(1998) (Hong Kong Chinese)	M	Mx	0.79	7.97	0.66	0.68	0.62
		Mn	0.77	8.82	0.58	0.61	0.60
	F	Mx	0.65	8.30	0.61	0.81	0.42
		Mn	0.69	6.66	0.64	0.82	0.47
Present study	M	Mx	0.57	11.20	0.51	0.80	0.33
		Mn	0.64	10.01	0.53	0.70	0.41
	F	Mx	0.52	12.90	0.42	0.60	0.27
		Mn	0.58	10.89	0.47	0.60	0.34

M, Male; F, female; Mx, Maxilla; Mn, Mandible.
r, correlation coefficient; r^2 coefficients of determination
SEE, standard errors of the estimates;

tablished probability tables suggesting the predicted space required to align the permanent upper and lower canines, as well as the first and second premolars by using the sum of the four lower permanent incisors. Tanaka and Johnston[4] presented prediction equations which provided similar values to Moyers prediction probability table. Even though there are some mentions that the sum of mesiodistal diameter of lower incisor used in the Moyers and the Tanaka and Johnston's method is not the best predictor for unerupted canine and premolar sums[11-13], these equations are still widely used.

The most important factors in the reliability of the data are the characteristics of the sample. The suitability of this study sample could be questionable owing to its small size (70 women, 108 men). However, odontometric data collected from adult samples can be used for children if the extent of dental attrition is minimal.

Definite racial and ethnic differences in tooth size have been emphasized in several studies[14,15]. Descriptive statistics also showed that the mesiodistal diameters of the mandibular incisors and the maxillary and mandibular canine and premolar segments were greater in men than those in women ($p<0.05$). Significant sexual dimorphism has also been noted in other studies[16,24-27].

Table 5 shows the r values for the buccal segments of each arch, the constants a and b, the SEE, and the r^2 of the maxillary and mandibular regression equations of Asian from different investigations. The correlation coefficients for the Korean population between the buccal segment of each arch and the mandibular incisors were found to be smaller than for Hong Kong Chinese[25] in both genders but higher than those for Thai boys[26].

The relative comparison of regression parameters from Thai studies[26] showed b value of 0.41 and 0.43 respectively for men which is smaller than our data. However, the b value in this study is smaller than for Hong Kong Chinese[25]. This study also showed larger constant a values for both genders in both arches than in Hong Kong Chinese[25].

The r^2 values are indicators of the predictive accuracy of the regression equations. This study showed greater r^2 values in both arches for men than in Thai boys[26] but smaller values than those in Thai girls[26]. For Hong Kong Chinese[25], the r^2 values in this study were smaller in both arches for both genders.

SEE indicates the error in use of the prediction equations. In this study, the SEE of men in the maxilla was the largest compared with other genders and other arches.

This study showed larger canine and premolar diameters than Tanaka and Johnston's[4] and Moyers studies[1] which might be due to the racial differences.

The results of this study are very similar to the previous study[16] for Korean sample, so these predic-

tion tables can be applied to Korean children. It is convenient to use and does not require complex equations.

Further investigations with a larger sample size and recently proposed methods would be needed to construct more representative and accurate prediction table for the Korean population.

Ⅴ. CONCLUSIONS

In order to construct probability prediction tables of mixed dentition for Korean children, 178 dental casts with a normal occlusion obtained from Yonsei University students were used. The mesiodistal diameter of all mandibular and maxillary canines and premolars and mandibular incisors were measured. Linear regression equations were established to predict the tooth width of the unerupted permanent canines and premolars. The prediction tables were then constructed . The results are summarized below:

1. There was a statistically significant sexual dimorphism in the tooth sizes ($p<0.05$).
2. The Tanaka and Johnston prediction equations and the Moyers charts(75%) underestimated the mesiodistal diameters of the unerupted canines and premolars in Korean children except for the female mandibular data.
3. The following regression equations of Korean were made:

$y = 11.20 + 0.51 \times$ (male, maxilla)
$y = 10.01 + 0.53 \times$ (male, mandible)
$y = 12.90 + 0.42 \times$ (female, maxilla)
$y = 10.89 + 0.47 \times$ (female, mandible)

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국문초록

한국인에서의 혼합치열기 공간분석

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이번 연구의 목적은 혼합치열기 아동에서 미맹출된 견치와 소구치의 크기를 예측하는데 있어서 한국인에 맞는 방정식을 만들기 위함이다.

미맹출 치아의 크기를 예측하는 것은 혼합치열기 교정 진단과 치료계획 수립에 있어서 매우 중요하다.

미맹출된 견치와 소구치 크기를 예측하는 방법은 몇가지가 있지만 그중에서도 가장 흔하게 쓰이는 것이 모이어의 예측표와 다나카와 존스턴의 방정식이 있다. 하지만 그것들은 백인을 위해서 제작된 것이고 치아 크기는 인종에 따라서 다르다고 알려져 있다.

이번 연구에서는 치아크기를 측정하여 하악 영구 절치의 크기 합과 견치 및 소구치의 크기 합 사이의 상관계수를 구하고 회귀방정식을 이용해서 한국인에 맞는 예측표를 만들었다.

연세대학교 치과대학에 재학중인 178명의 한국 학생(남 108명, 여 70명, 평균연령 21.63)을 대상으로 실험하였다. 영구치의 근원심 폭경을 석고모형상에서 calipers를 이용해서 측정하였다. 성별간의 치아 크기는 차이가 있었다 ($p<0.05$).

Correlation coefficient는 0.57에서 0.64의 범위였고, standard errors of the estimates는 여성에서 0.6으로써 남성보다 우수하였다. r^2값은 0.27에서 0.41의 범위를 나타내었다.

주요어 : 혼합치열기 공간분석, 치아크기, 예측표