

Predicting the size of unerupted canines and premolars of the maxillary and mandibular quadrants in an Iranian population

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The aim of this investigation was to examine the accuracy of Moyers probability tables and the Tanaka and Johnston prediction equations in predicting the size of unerupted canines and premolars of the maxillary and mandibular quadrants in an Iranian population and to derive a standard formula for it.

Methods. *Out of a sample of 280 subjects, 50 (25 males and 25 females) were selected by specific inclusion criteria. An electronic digital caliper was used to read the nearest 0.01mm. The teeth measurements derived were compared with those predicted from Tanaka Johnston equations and Moyers probability tables and then standard regression were developed.*

Results. *Tanaka and Johnston regression equations overestimate the mesiodistal width of permanent canines and premolars. There were no statistically significant differences between actual mesiodistal width of canines and premolars and the predicted width from Moyers charts at 65% for the lower and upper arches in male subjects and for the lower arch in females but none of the probabilities has good accuracy for the upper arch in females. For the newly developed regression equations, the correlation coefficients between the sum of the mandibular incisors and the sum of the canine and premolars were 0.709 (for lower) and 0.539 (for upper) in subjects.*

Conclusions: *Tanaka and Johnston overestimate the actual size for Iranian teeth widths. Moyers method can be used at 65% probability level for male subjects and at the 75% and 85% level for upper arch and the 50% and 65% level for lower arch in female subjects.*

Keywords: *Moyers, Tanaka and Johnston, Tooth size prediction.*

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INTRODUCTION

Although approximately 5% of the populations have some degree of discrepancy among the size of individual teeth,⁽¹⁾ and variation in the size and shape of

teeth is predominantly genetically determined,^(2,3) predicting the size of unerupted teeth during mixed dentition is a critical factor to evaluate the space requirements for unerupted permanent teeth. Many methods have been reported for obtaining this aim. Among these methods, the Moyers probability tables,⁽⁴⁾ and the Tanaka and Johnston prediction equations and tables⁽⁵⁾ are usually applied. However, the development of these two methods was based on a data derived from a population methods of Northern European descent. Therefore these predictions have undermined accuracy when applied for Iranian population. The aims of this investigation are to test the accuracy of both the Moyers and the Tanaka and Johnston methods in an Iranian population and to derive a standard formula for this specific population.

MATERIALS AND METHODS:

280 dental students of Tehran Medical University were examined clinically and 50 subjects (25 males and 25 females) were selected on the following criteria:

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Table 1. Descriptive statistics (mm) of the predicted and actual mesiodistal diameters of maxillary canine and first and second premolars.

Sex	Tooth group	Mean	SD	Range	Standard error of the mean
Combined	Sum of incisors	23.0124	1.11162	20.55-25.56	0.15721
	Sum of lower canine and premolars	21.1499	1.00292	18.86-23.14	0.14183
	Sum of upper canine and premolars	21.6304	0.94631	19.45-23.44	0.13383
Female	Sum of incisors	22.7508	1.11724	20.55-24.45	0.22345
	Sum of lower canine and premolars	20.7659	1.04913	18.86-22.84	0.20983
	Sum of upper canine and premolars	21.3356	0.95186	19.45-23.44	0.19037
Male	Sum of incisors	23.2740	1.06399	21.28-25.56	0.21280
	Sum of lower canine and premolars	21.5340	0.80352	20.16-23.14	0.16070
	Sum of upper canine and premolars	21.9252	0.86094	20.42-23.40	0.17219

SD, standard deviation.

(The number of subjects was determined by a pilot study: $sd = 0.35\text{mm}$, $a = 0.05$, $d = 0.1$,

$$N = \frac{(Z_1 - \frac{\alpha}{2})^2 Sd^2}{d^2} = \frac{(1.96)^2 (0.35)^2}{(0.1)^2} = 47.06 = 50$$

- 1) The patient had to be Iranian background for at least one prior generation, that is, both parents had to be of Iranian background.
- 2) The dental casts had to be of high quality and free of distortion.
- 3) The teeth measured had to be free of restorations (except class I restorations), fractures, or proximal caries as determined by bitewing radiographs and dental casts.
- 4) The subjects had to be class I Molar and canine relationship with normal overjet and overbite (0% to 50% overbite and 0 to 3 mm of overjet).
- 5) The subject had to be free of crowding, spacing, rotation and history of previous orthodontic treatment.

The mesiodistal width of a tooth was obtained by measuring the greatest distance between contact points on proximal surfaces. An electronic digital caliper (Digenetic calipers, Mitutoyo Corporation, Tokyo, Japan) was used to read to the nearest 0.01mm. Measurements were made as described by Seijel (T-J 22) and Moorrees *et al* (T-J 23).^(6,7)

The teeth measured were the mandibular permanent incisors and the maxillary and mandibular permanent canines, as well as the first and second premolars.

The measurements were made by two examiners in 32 of casts in the sample. The correlation of the first and second measurements was calculated to determine the measurement reliability. The correlations ranged from $r = 83.6\%$ to $r = 84.2\%$. The error values of mesiodistal widths ranged from 0.14 to 0.22mm. The values were considered clinically acceptable.

All subsequent measurements on the orthodontic patients sample were taken only once, to simulate the conditions of an orthodontic practice.

Table 2. Regression values of actual sum of permanent canines and first and second premolars of Iranian subjects and those predicted from Tanaka and Johnston equations for the same subjects.

Group	SD	95% Confidence interval
Combined (226)		
Upper	0.04	1.47_ 1.49
Lower	0.04	-0.22_ -0.18
Male (130)		
Upper	0.12	- 0.58_ - 0.48
Lower	0.55	-1.40_ -1.31
Female (96)		
Upper	0.015	-1.11_ -1.10
Lower	0.17	-1.68_ -1.54

SD, standard deviation.
*P< 0.05.
**P <0.0001.

Statistical analysis

The measurements were then compared with the predicted values obtained with the Tanaka and Johnston prediction equations and the Moyers probability charts.

Using these data, regression equations were formulated to be used clinically for the prediction of tooth size in the similar Iranian population. These least square regression equations were calculated as follows:

$$Y = A + B (x)$$

Where Y = the predicted size of the canine and premolars in one quadrant in millimeters.

X = the measured width of the four permanent mandibular incisors in millimeters.

A + B = constants to be derived.

RESULTS

Descriptive statistics for three groups of teeth measured are shown in Table 1. Table 2 shows the difference between the regression values of the actual sum of the permanent canine and the first and second premolars in test group and those predicted from Tanaka and Johnston equations. Tanaka and Johnston regression equations overestimate the mesiodistal width of permanent canines and premolars. Then regression

equations were derived in male and female subjects and both sexes combined for maxillary and mandibular arches.

Regression parameters for prediction of the sum of widths unerupted upper and lower permanent canines and premolars for the Iranian male and female subjects are presented in Table 3. The correlation coefficients between the lower arch incisors and the sum of canine and premolars are 0.682 (for the mandible) and 0.562 (for the maxilla) in the males and 0.701 and 0.454 in the females. And 0.709 and 0.539 respectively for both sexes combined.

The standard error of estimate ranges from 0.06 to 0.086mm which is smaller in males. The coefficient *ab* values range from -1.968 to 1.569 ($P < 0.001$) and the 95% confidence interval value ranges from 0.387 to 0.658.

The difference (in mm) between the mean values of the actual sum of maxillary and mandibular permanent canine and first and second premolars of Iranian subjects, and those predicted from Moyers charts for the same subjects is presented in Tables 4 and 5. There was no statistically significant difference between actual mesiodistal widths of canines

Table 3. Regression parameters for prediction of sum of unerupted upper and lower permanent canine and premolars widths for Iranian male and female subjects.

Sex	Tooth group	Coefficient of correlation (r)	Regression coefficient a b		95% Confidence interval	SEE	P value
Combined	Sum of lower canine and premolars	0.70	6.42	0.64	-1.040-1.66	0.07	0.000
	Sum of upper canine and premolars	0.53	11.06	0.45	1.3801.56	0.08	0.000
Male	Sum of lower canine and premolars	0.68	9.54	0.51	-1.070-1.14	0.06	0.000
	Sum of upper canine and premolars	0.56	11.34	0.45	-0.100-0.30	0.07	0.000
Female	Sum of lower canine and premolars	0.70	5.78	0.65	-1.260-1.96	0.07	0.000
	Sum of upper canine and premolars	0.45	12.53	0.38	-0.270-0.78	0.08	0.000

SEE, standard error of estimate.

Table 4. The difference (in mm) between the mean values of actual sum of maxillary permanent canine and first and second premolars of Iranian subjects and those predicted from Moyers charts for the same subjects

Percentile probability (%)	Males			Females		
	Mean difference (mm)	SD	95% CI	Mean difference (mm)	SD	95% CI
5	2.26**	1.19	1.78-2.74	2.61**	1.03	2.21-3.01
15	0.74**	1.15	1.28-2.20	1.96**	1.03	1.56-2.36
25	1.44**	1.15	0.98-1.90	1.59**	1.02	1.19-1.99
35	1.20**	1.18	0.73 -1.67	1.29**	1.02	0.89-1.69
50	0.85**	1.15	0.39 - 1.31	0.93**	1.01	0.53-1.33
65	0.54*	1.15	0.08-1.00	0.49	1.01	0.09-0.89
75	0.28	1.14	-0.17-0.74	0.19	1.01	-0.21-0.59
85	0.01	1.14	-0.47-0.44	-0.17	1.00	- 0.57-0.23
95	- 0.54*	1.11	-0.99- -0.10	- 0.81**	1.01	- 1.21- -0.58

CI, confidence interval. SD, standard deviation. * $P < 0.05$. ** $P < 0.001$.

Table 5. The difference (in mm) between the mean values of the actual sum of permanent mandibular canine and first and second premolars of Iranian subjects and those predicted from Moyers charts for the same subjects.

Percentile probability (%)	Mean difference (mm)	Males		Females		
		SD	95% CI	Mean difference (mm)	SD	95% CI
5	2.73**	1.15	2.07-2.53	2.82**	1.64	2.49-3.15
15	2.03**	1.15	1.46-1.92	2.22**	1.64	1.89-2.55
25	1.60**	1.13	1.10 -1.42	1.87**	0.99	1.66-2.07
35	1.24**	1.15	0.77-1.23	1.52**	1.63	1.19-1.85
50	0.80*	1.13	0.40-0.72	1.17**	0.99	0.96-1.37
65	0.33	1.11	- 0.16-0.45	0.77**	1.54	0.45-1.08
75	-0.16**	1.29	- 0.29-0.03	0.47**	0.99	0.26-0.67
85	-0.42**	1.10	- 0.73-0.27	0.06	1.62	- 0.27-0.39
95	-1.16**	1.07	-1.30-0.98	- 0.54**	0.99	- 0.74-0.33

CI, confidence interval. SD, standard deviation. * $P < 0.05$. ** $P < 0.001$.

and premolars and the predicted width from Moyers charts at the confidence levels following:

- 1) 65% confidence level for the lower and upper arches in male subjects.
- 2) 75% confidence level if the combined mesiodistal width of the permanent incisors is between 20.5-23mm and 85% confidence level if it is between 23.5-24/5.
- 3) 50% confidence level if the combined mesiodistal width of the permanent incisors is between 20.5 and 21.5 and 65% confidence level if it is between 22 and 24.5.

In addition, tables for prediction are most accurate when the combined mesiodistal width of permanent incisor is between 21.5-25mm, the sum of width of canine, and premolars from sum of width of the lower incisors is derived and presented in tables 6 and 7.

DISCUSSION

In different studies, inclusion and exclusion criteria consist of one of the three approaches:

- 1) The studies that select their subjects from orthodontic patients.^(8,9)
- 2) The studies that select their subjects randomly from society.⁽¹⁰⁾
- 3) The studies that select subjects with class I Angle relationship^(13, 12, 11)

This study, used the third approach because of its higher accuracy.

A comparison shows that the mean sizes of Iranian permanent teeth are smaller than those of Tanaka and Johnston, Schirmer and Witshire and Lee-Chan studies^(5,9,12) revealing that these equations are not accurate for Iranian subjects.

The presence of sexual dimorphism has been indicated in previous studies.^(1, 14,15) The former study also indicates the presence of sexual dimorphism in particular between the canines while the incisors show the least difference between boys and girls.

The Tanaka and Johnston method is one of the most common methods for predicting the size of unerupted teeth which is derived from northwestern European subjects, and it may not be applicable when used for other ethnic groups. In the former study the Tanaka and Johnston method overestimated the actual widths of Iranian teeth. The difference between regression values ranged from 0.12 to 1.96, which may be attributed to different racial groups. Therefore, it was concluded that a method developed for other races is not accurate for Iranian subjects and a specific one should be derived.

The correlation coefficients between the sum of mesiodistal widths of the four permanent mandibular incisors and the permanent canine and premolars of each arch for our subjects range from 0.454 to 0.709 (standard error 0.060-0.086). This range of correlation coefficient is comparable to those of preceding studies.^(18, 17, 16, 12, 10, 8)

The slope of simple linear regression ranged from 0.38 to

Table 6. Probability table for canine, first and second premolar width from sum of lower incisor width (maxilla)

25.5	25.0	24.5	24.0	23.5	23.0	22.5	22.0	21.5	21.0	20.5	20.0	19.5	21.12/%
24.4	24.2	23.9	23.7	23.5	23.2	22.9	22.8	22.5	22.3	22.1	21.8	21.6	95
23.9	23.7	23.4	23.2	23	22.7	22.4	22.3	22.0	21.8	21.6	21.3	21.1	85
23.5	23.3	23.0	22.8	22.6	22.3	22.1	21.9	21.6	21.4	21.2	20.9	20.7	75
23.1	22.9	22.6	22.4	22.2	21.9	21.7	21.5	21.2	21.0	20.8	20.5	20.3	65
22.8	22.6	22.3	22.1	22.9	21.6	21.4	21.2	20.9	20.7	20.5	20.2	20.0	50
22.5	22.3	22.0	21.8	21.6	21.3	21.1	20.9	20.6	20.4	20.2	19.9	19.7	35
22.1	21.9	21.6	21.4	21.2	20.9	20.7	20.5	20.2	20.0	19.8	19.5	19.3	25
21.7	21.5	21.2	21.0	20.8	20.5	20.3	20.1	19.8	19.6	19.4	19.1	18.9	15
21.2	21.0	20.7	20.5	20.3	20.0	19.8	19.6	19.3	19.1	18.9	18.6	18.4	5

Table 7. Probability table for canine, first and second premolar width from sum of lower incisor width (mandible)

25.5	25.0	24.5	24.0	23.5	23.0	22.5	22.3	21.5	21.0	20.5	20.0	5.19	21.12/%
24.2	23.8	23.5	23.2	22.8	22.5	22.2	21.9	21.5	21.2	20.9	20.6	20.2	95
23.7	22.3	23.0	22.7	22.3	22.0	21.7	21.4	21.0	20.7	20.4	20.1	19.7	85
23.3	22.9	22.6	22.3	21.9	21.6	21.3	21.0	20.6	20.3	20.0	19.7	19.3	75
22.9	22.5	22.2	21.9	21.5	21.2	20.9	20.6	20.2	19.9	19.6	19.3	18.9	65
22.6	22.2	21.9	21.6	21.2	20.9	20.6	20.3	19.9	19.6	19.3	19.0	18.6	50
22.3	21.9	21.6	21.3	20.9	20.6	20.3	20.0	19.6	19.3	19.0	18.7	18.3	35
21.9	21.5	21.2	20.9	20.5	20.2	19.9	19.6	19.2	18.9	18.6	18.3	9.17	25
21.5	21.1	20.8	20.5	20.1	19.8	19.5	19.2	18.8	18.5	18.2	17.9	17.5	15
21.0	20.6	20.3	20.0	19.6	19.3	19.0	18.7	18.3	18.0	17.7	17.4	17.0	5

0.45 for maxillary teeth in female and male subjects which is comparable with Hashim, Al-Shalan's study.⁽¹³⁾

The following equations were derived for the size prediction of maxillary and mandibular canines and premolars in male and females:

- 1) In the maxilla: $Y = 11.04 + 0.46(x)$
 - A. For male subjects: $Y = 11.34 + 0.46(x)$
 - B. For female subjects: $Y = 12.53 + 0.39(x)$
- 2) In the mandible: $Y = 6.42 + 0.64(x)$
 - A. For male subjects: $Y = 9.54 + 0.52(x)$
 - B. For female subjects: $Y = 5.79 + 0.66(x)$

(Where X = Mesiodistal width of four mandibular incisors in mm and

Y = Mesiodistal width of the canine and premolars in one quadrant in mm).

There were no statistical differences between the actual mesiodistal widths of canines and premolars and the predicted width from Moyers charts at the following confidence levels:

- 1) 65% confidence level for the lower and upper arches in male subjects.
- 2) 75% confidence level if the combined mesiodistal width of the permanent incisors is between 20.5 and 23mm and 85% confidence level if it is between 23.5 and 24.5.
- 3) 50% confidence level if the combined mesiodistal width of the permanent incisors is between 20.5 and 21.5 and 65% confidence level if it is between 22 and 24.5.

(most accurate when the combined mesiodistal width of the permanent incisors is between 21.5-25mm)

CONCLUSIONS

- 1) There is presence of sexual dimorphism in the sum of the mesiodistal widths of the canine and the premolars.
- 2) The Tanaka and Johnston method overestimated the actual width of Iranian teeth.

These regression equations were derived for Iranian subjects:

- 1) In the maxilla: $Y = 11.04 + 0.46(x)$
 - A. For male subjects: $Y = 11.34 + 0.46(x)$
 - B. For female subjects: $Y = 12.53 + 0.39(x)$
- 2) In the mandible: $Y = 6.42 + 0.64(x)$
 - A. For male subjects: $Y = 9.54 + 0.52(x)$
 - B. For female subjects: $Y = 5.79 + 0.66(x)$

(Where X = Mesiodistal width of four mandibular incisors in mm and

Y = Mesiodistal width of the canine and premolars in one quadrant in mm)

- 4) The Moyers method can be used at 65% probability levels for male subject and at the 75% and 85% level for upper arch and the 50% and 65% level for lower arch in female subjects.

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