Applicability of Tanaka & Johnston Analysis and Prediction of New Equation for Contemporary Nepalese Sample

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ABSTRACT

Objective: To examine applicability of Tanaka & Johnston prediction in Nepalese sample.

Materials & Method: A total of 100 samples of the age ranging from 14-24 years were selected for the measurement of mesio-distal widths of mandibular permanent incisors, and maxillary and mandibular permanent canines and premolars. Descriptive statistics was calculated and paired t-test was carried out to find the difference between predicted and actual values of canine and premolar mesio-distal widths. The linear regression equation was performed to develop new equation for Nepalese sample.

Result: Mean differences were observed in actual and predicted values between the present study and the reports of Tanaka & Johnston. Coefficient of correlation was found for maxilla, r=0.52 and mandible, r =0.51.

Conclusion: The equations and charts used for other ethnic sample do not accurately predict for Nepalese sample. The linear regression equation developed in this study can be used for orthodontic treatment for Nepalese patients.

Key words: arch length discrepancy, mesio-distal width, mixed dentition, prediction

INTRODUCTION

An important aspect of orthodontic diagnosis in the mixed dentition is the determination of tooth size-arch length discrepancy. The operator who provides care for children and adolescent should be able to assess the developing malocclusion and probably reduce the irregularity in adult dentition.

It is believed that most of the malocclusions start during mixed dentition period, and also early treatment is becoming popular in the contemporary orthodontic practice.[1] Space analysis during mixed dentition is a fundamental step to determine any tooth size-arch length discrepancy. In such cases it is important to predict the deficiency in arch space in advance before the permanent posterior teeth erupt for evaluating whether treatment will involve space maintenance, serial extraction, space regaining, proximal stripping etc.[1-5]

There are three popular methods for predicting the mesio-distal widths of unerupted permanent canine and premolars.

1. Direct measurement from radiograph with or without the use of a prediction formula,[1, 6]
2. Use of prediction chart based on measurements of other erupted permanent teeth,[7,8]
3. Combination of previous two methods.[9,10]

The most accurate prediction is achieved by using both radiograph and dental cast. However, in a developing country like ours the availability of x-ray service and quality of available radiograph is questionable. Due to these limitations non-radiographic technique i.e. the use of dental cast alone would be the choice.

Tanaka & Johnston[8] used north-western European natives for predicting the size of the unerupted canines and premolars by using the mesiodistal widths of the four permanent mandibular incisors. Because of its simplicity researchers have investigated the applicability of Tanaka & Johnston analysis in various ethnic groups, however the accuracy of these predictions are in question when applied to a population of different ethnic group.[11-15]

The present study was designed to evaluate the applicability of Tanaka & Johnston method in predicting the size of unerupted permanent canine and premolars of the Nepalese samples.

MATERIALS AND METHOD

A total of 100 study models of 50 male and 50 female samples were chosen from the Department of Orthodontics, Kantipur Dental College & Hospital, Kathmandu. The age of the subjects ranged from 14-24 years. The samples were selected according to the inclusion criteria of Class I molar and canine relation, presence of all permanent teeth in each arch with or without second and third molars, teeth without anomalies in number, shape, size and structure. All samples were native Nepalese. None of the subject had undergone orthodontic treatment. Teeth with fractures, proximal caries, proximal restorations and attrition were excluded. The study models were obtained from alginate impression and were poured in dental stone. Sliding vernier caliper with an accuracy of 0.1mm was used to measure the tooth size. The mesio-distal dimension of the teeth were measured according to the method described by Moorrees & Reed.[16] The maximum dimension of the tooth crown between the contact points on its proximal surface was measured. The study was conducted during March 2013.

Sum of the mesio-distal widths of following groups of teeth were calculated;

a) Mandibular incisors
b) Maxillary canines and premolars
c) Mandibular canines and premolars

The present study used Tanaka & Johnston equation's constant 'a' to predict unerupted mesio-distal width of canines and premolars of both maxillary and mandibular arches.

To predict values for maxillary arch; half of the mesio-distal widths of lower incisors were added to constant 'a' (11mm). And, to predict values for mandibular arch; half of the mesio-distal widths of lower incisors were added to constant 'a' (10.5 mm).

Tanaka & Johnston equations are as follows;

Maxillary left and right permanent canine and both premolar width; $Y = 11.0 + 0.5 X$

Mandibular left and right permanent canine and both premolar width; $Y = 10.5 + 0.5X$

Where, Y is the sum of permanent canine and both premolars of each side and X is the sum of the width of the four mandibular permanent incisors.

Data were analyzed using SPSS Version 17.0. Descriptive statistics including mean, standard deviation and range were calculated and paired Student's t-test was done to compare the mean of actual and predicted mesio-distal dimensions of canines and premolars of both maxillary and mandibular arches.

Linear regression equations; $Y = a + bX$ was used to calculate equation of the sum of the maxillary and mandibular canine and premolars based on the sum of mandibular incisors, where 'Y' represents the predicted combined mesio-distal width of the canine and premolars (dependent variable), and 'X' represents the measured mesio-distal width of the mandibular incisors (independent variable). Values 'a' and 'b' are constant.

RESULT

Descriptive statistics of the summation of right and left canines and premolars of both maxilla and mandible are presented in Table 1. The mean, standard deviation and range of the actual and predicted values of the Nepalese sample are presented. The mean predicted values derived from Tanaka & Johnston equation is slightly higher than the actual mean value of canine and premolars for both upper and lower arches.

Paired t-test between the actual and predicted values of canine and premolars widths shows no significant difference (Table 2).

Table 1: Descriptive statistics for the summation of the actual and predicted mesio-distal widths

(in mm)	Mean	SD	Maximum	Minimum
ΣLI	21.34	1.37	24.50	18.75
ΣACPMU	20.07	1.06	22.63	17.38
ΣACPML	19.65	1.12	22.88	17.00
ΣPCPMU	21.71	0.81	23.75	20.00
ΣPCPML	21.23	0.80	23.25	19.50

(LI-lower incisor, ACPMU-actual canine premolar width upper, ACPML-Actual canine premolar width lower, PCPMU-predicted canine premolar width upper, PCPML-predicted canine premolar width lower)

Table 2: Paired sample t-Test for the difference between the mean values of actual sums of mesio-distal widths

	Mean difference	SD (mm)	95% CI (mm)	*p*-value
Maxilla	0.17	1.24	2.01-1.31	.001*
Mandible	0.18	1.28	1.94-1.21	.001*

*SD-standard deviation, CI-confident interval, *statistically significant*

Based on regression equation for prediction of mesio-distal widths of canine and premolars (dependent variables) using mesio-distal widths of the mandibular incisors (independent variables); correlation coefficient (r), Standard error of estimation (SEE) and the 95% confidence intervals (CI) were depicted (Table 3). Depending on these values the equations were as follows:

Maxilla: Y=11.43+0.40(X)

Mandible: Y=10.30+0.43(X)

Table 3: Regression parameters for prediction of mesio-distal widths

	Correlation coefficient (r)	Constant		Standard error of estimate (SEE)	Coefficient of determination (r^2)
		a	b		
Maxilla	0.52	11.43	0.40	0.91	0.27
Mandible	0.51	10.30	0.43	1.00	0.26

DISCUSSION

Prediction of mesio-distal widths of canine and premolars during late primary dentition or early mixed dentition is critical period for prevention and interception of developing malocclusion.[15] Among various mixed dentition analyses; regression equation based on the measurement of erupted permanent teeth are most commonly used. The present study was conducted to evaluate the applicability of Tanaka & Johnston equation for native Nepalese sample. Tanaka & Johnston prediction of the widths of unerupted teeth in a population provides inaccurate estimates due to racial and ethnic variations of tooth size.[3-15,17] Studies show that Tanaka & Johnston prediction overestimates mesio-distal widths of the teeth, this finding was apparent in cases of Asian Americans,[4] Senegalese,[21] black South Africans,[11] and Saudi Arabians.[14] Present study also shows the overestimation of both maxillary and mandibular buccal segment. The use of overpredicted or underpredicted values influence the diagnosis and treatment planning.

Table 4: Comparison of regression constant values among various population groups

Population group	Arch	Correlation coefficient (r)	Constant		Standard error of estimate (SEE)	Coefficient of determination (r2)
			a	b		
Thai[15]	mx	0.60	11.87	0.47	0.84	0.36
	md	0.64	10.30	0.50	0.82	0.41
Black American[17]	mx	0.62	11.93	0.44	-	0.38
	md	0.70	9.93	0.52	-	0.49
Negro population[18]	mx	0.65	10.18	0.52	0.87	0.42
	md	0.07	8.30	0.64	0.94	0.49
Hong Kong Chinese[19]	mx	0.69	7.97	0.66	0.68	0.42
	md	0.77	8.82	0.58	0.61	0.60
South Arabian[14]	mx	0.65	7.20	0.63	-	0.42
	md	-	8.60	0.55	-	0.49
Senegalese[20]	mx	0.68	9.87	0.53	0.71	0.46
	md	0.73	5.67	0.70	0.81	0.54
Pakistani[21]	mx	0.59	10.52	0.48	0.82	0.35
	md	0.65	8.56	0.54	0.79	0.42
Tanaka & Johnston[8]	mx	0.63	10.41	0.51	0.86	0.40
	md	0.65	9.18	0.54	0.85	0.42
Nepalese (present study)	mx	0.51	11.43	0.40	0.91	0.27
	md	0.52	10.30	0.43	1.00	0.26

mx-maxillary, md-mandibular

The correlation coefficient derived for Nepalese samples between the buccal segments of each arch and the mandibular incisors are lesser than that of the Hong Kong,[19] black Americans,[17,18] Senegalese[21] and the Tanaka & Johnston values[8] (Table 4). In our study correlation coefficient (r) is above 0.50 for both maxilla and mandible, which shows that these regression equations can be placed into good clinical orthodontic use. The coefficient of determinants (r^2), which indicates predictive accuracy of regression equation is lower in the present study as compared to other studies.

The standard error of estimate (SEE) in the present study is higher compared to previous studies. However it has been found that; lower the SEE, better the predictive value. Lesser 'r^2' and higher SEE values in the present study may be due to smaller sample size and due to mixed ethnic samples within the Nepalese population.

In comparison with other studies, constant 'b' is slightly lower in our study. Constant 'b' of 0.5 value facilitates practical application of the prediction equation. Constant 'a' value for mandible and maxilla appears to overlap with the values of other studies.[15,17-20] Constant 'a' of 11.43 for maxilla and 10.30 for mandible are similar to that of the Thai and black American population.[15,17,18]

Further investigation with larger sample size considering ethnic diversity among Nepalese population is required to collect more representative data. It would be more constructive and appropriate to undertake further evaluation of the prediction values, particularly to reduce the prediction error.

CONCLUSION

The regression equations proposed in the present study are able to predict the widths of the maxillary and mandibular permanent canine and premolars. These simplified equations are easy and practical to use and require no sophisticated software or instrument. However, due to possible influence of racial and ethnic difference in different population groups; the proposed values must be tested in other groups to confirm its applicability and consistency.

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