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Dentistry Section

Applicability of Tanaka Jhonston Method and Prediction of Mesiodistal Width of Canines and Premolars in Children

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ABSTRACT

Introduction: Essential part of diagnostic procedures in mixed dentition analysis is to determine adequate space available for the erupting permanent teeth. Various methods of analysis for mixed dentition are available; among them Tanaka Johnston method of space analysis for children was developed for North American children and is widely used. Its reliability among different racial and ethnic groups is yet to be determined.

Aim: To check the applicability of Tanaka Jhonston method and to derive the mesiodistal width of unerupted canines and premolars and also derive new regression equations for Bangalore population.

Materials and Methods: Considering the selection criteria, 400 subjects of Bangalore aged 13-16 years were randomly selected and study models were prepared. Mesiodistal widths of permanent lower incisors, canines and premolars were measured. Estimated width of upper, lower canines and premolars were also derived using Tanaka Jhonston method. Data was utilized to predict mesiodistal widths of erupting permanent canines and premolars. Descriptive analysis, independent student t-test, correlation and regression analysis were carried out.

Results: Measured and estimated widths of upper and lower canines and premolars were compared and the results showed that estimated widths of upper and lower canines and premolars over estimated as to the actual measurements. A new regression equation was developed by using the formula Y=a+b(X) where Y= predicted width of canine and premolars, "a" and "b" are the constants and X= lower incisal width. Regression equations for males and females were derived separately.

Conclusion: The original Tanaka Jhonston method over estimated for local Bangalore population. New regression equations and prediction tables were derived for males and females separately, which should be more conveniently used chairside by the clinician.

Keywords: Mixed dentition analysis, Non-radiographic analysis, Prediction tables, Regressions

INTRODUCTION

In treatment planning among children, important aid is prediction of space required for unerupted canines and premolars. This helps in determination of space required for eruption of canines and premolars by mixed dentition analysis. A majority of children will be benefited if such developing malocclusion can be diagnosed and treated early. In the mixed dentition phase, one of the problems is related to arch length and tooth size discrepancy. In order to identify such space discrepancies, different methods of mixed dentition space analyses have been introduced. Most commonly used methods were Moyers mixed dentition analysis and Tanaka Jhonston analysis [1]. These analyses predict the mesiodistal width of the unerupted premolars and canines and the amount of space available in the dental arch for the alignment of the succedaneous teeth.

Different methods of predicting the sizes of permanent canines and premolars have been mentioned in literature [1]. GV Black and others attempted earlier to estimate tooth sizes based on tables of average mesiodistal widths of canines and premolars [2]. Other methods of prediction were based on estimating the size of permanent teeth on radiographs alone or in combination with crown diameters measured on dental casts [3]. One method that is widely used correlates the mesiodistal crown diameters of erupted mandibular permanent incisors as the predictor for estimating the size of unerupted canines and premolars [4].

Tanaka Johnston method is a simplified analysis proposed by Tanaka for chairside evaluation. Original Tanaka Johnston analysis was done on population of North European descent [5]. But its applicability has to be evaluated in Bangalore population.

It has been shown that variations in tooth sizes occur based on ethnicity of a particular population and within population [6], different racial groups [7]. Sexual dimorphism with respect to tooth size also prevails [8]. As Bangalore is an industrial hub, it attracts people from various part of India resulting in a cultural intermingling.

Very few studies in literature have been cited using Tanaka Johnston equations for Indian population [5,9]. Therefore, the objectives of this study were to determine the mesiodistal width of canines and premolars and to check the applicability of Tanaka Jhonston's method in children of Bangalore population.

As the data collected is same as that of the other studies but this was interpreted and analysed by using different method i.e., Tanaka Jhonston's method for Bangalore population [10].

MATERIALS AND METHODS

A cross-sectional study was conducted on children of age groups varying from 13-16 years in the Department of Pedodontics and Preventive Dentistry, Rajarajeswari Dental College and Hospital Bangalore. As per the guidelines given by Tashildhar administrative system Karnataka, questions regarding numbers of years of stay (min of 10 years) in Bangalore and language Kannada as their mother tongue were asked. Sample comprised of 400 school children out of whom 200 were boys, 200 were girls with Kannada as their mother tongue were included for the study. Bangalore was divided into north and south, from which two schools were randomly selected from each zone. From these schools, 200 children from North and 200 from South Bangalore were selected by stratified random sampling.

The criteria for selection of samples were: A. Children aged 13-16 years were considered. B. Fully erupted permanent teeth in all arches except for third molars. C. Caries free permanent teeth. D. Children who underwent orthodontic treatment and having any congenital craniofacial anomalies, significant attrition and restorations were excluded.

Selected children's maxillary and mandibular arches impression were made and study models were then prepared. The greatest mesiodistal crown width of each tooth was measured between the contact points, with the calliper placed parallel to the occlusal and vestibular surfaces. This method was reported to be highly accurate for measuring mesiodistal crown widths [11]. Measurements of the mesiodistal widths of mandibular incisors, maxillary and mandibular canines and premolars were made with the help of Vernier gauge calliper calibrated to 0.01 of a millimeter. Standard method was used to check measurement reliability [12], where a single investigator does all measurements after carefully marking the maximum mesiodistal width on the teeth to be measured and then remeasures certain randomly selected casts. The coefficients of test reliability on 40 randomly selected casts were calculated and r value was 0.97 so the reliability was confirmed.

The predicted width of the canine, first and second premolar, was calculated by measuring the sum of mesiodistal width of lower incisors and using the formula given by Tanaka-Johnston; Y=I/2+10.5, for lower arch, Y=I/2+11, for upper arch [13]. (I is the sum of incisors and Y is the predicted width of sum of canine and premolars, on one side of the arch).

The actual widths of the upper and lower canines and premolars were calculated for the left and right sides and their mean value was added to deduce the actual combined width of canines and premolars but the average difference between the right and left sides did not differ statistically among the teeth in the upper and lower arch.

STATISTICAL ANALYSIS

The data collected was subjected to statistical analysis using Statistical Software Package for Social Sciences (SPSS) software version 22.0. Descriptive analysis, Independent Student t-test, correlation and regression analysis, separate probability tables for males and females were done. Level of significance of study was set at $p<0.05$.

RESULTS

The results revealed that estimated Lower Canine Premolar width (LCPM) was more when compared to actual measurements with a mean difference of 1.80 mm, which was statistically significant, at $p<0.001$. Similarly the Estimated Upper Canine Premolar width (UCPM) was more when compared with actual measurements with a mean difference of 0.70 mm which was also statistically significant, at $p<0.001$ is presented in [Table/Fig-1].

	N	Minimum	Maximum	Mean	SD	Mean Diff (in mm)	p-value
Sum of lower incisors	400	19.0	28.7	23.70	1.84		
Measured_LCPM	400	18.2	24.5	21.28	0.81	1.80	<0.001*
Estimated_LCPM	400	20.0	24.9	22.35	0.92		
Measured_UCPM	400	19.8	24.4	21.86	0.90	0.70	<0.001*
Estimated_UCPM	400	20.5	25.4	22.85	0.92		

[Table/Fig-1]: Shows descriptive statistics for combined mesiodistal widths of lower incisors and comparison of estimated and measured width (in mm) of canine premolars using student paired t-test.
*Statistically significant
*LCPM: Lower Canine Premolar width, UCPM: Upper Canine Premolar width

The current study results revealed that the Tanaka Johnston method was significantly over estimating the width for unerupted canine premolar for both the upper and lower arches, hence there was a need to derive the population specific equation.

Accordingly, the new regression equations for prediction of Mesiodistal widths of canines and premolars segments for both arches during the mixed dentition period for the study population were derived through linear regression analysis.

The regression equation was expressed as Y=a+b(X) where Y=Mesiodistal widths of canines and premolars to be predicted for the upper and lower arches, "a" and "b" are constants which are to be derived, X = Combined mesiodistal width of lower incisors. The parameters for prediction equations of maxillary and mandibular arches were derived separately.

The canine premolar segment in maxillary arch showed a coefficient of correlation of 0.461 and that of mandibular arch showed a coefficient of correlation of 0.508 and the standard error of estimate was 0.517 in maxilla, 0.454 in mandible is presented in [Table/Fig-2].

The test results demonstrated a statistically significant difference in the LCPM width between the genders, with males having a significantly higher width than females p=0.02. A borderline significance (p=0.06) was observed with respect to the combined mesiodistal width of incisors, with males having an increased width than females. However, the UCPM did not differ significantly between the genders (p=0.44) is presented in [Table/Fig-3].

Canine premolar segment	Coefficient of correlation	Regression coefficients		SEE (in mm)
		A	B	
Maxillary	0.461	16.52	0.26	0.517
Mandibular	0.508	15.95	0.23	0.454

[Table/Fig-2]: Parameters for prediction equations of maxillary and mandibular arch.
Note: SEE - Stdandard error estimate

Parameters	Sex	N	Mean	SD	SEM	Mean Diff	t	p-value
LI (in mm)	Males	200	23.87	2.15	0.15	0.35	1.922	0.06
	Females	200	23.52	1.43	0.10			
LCPM (in mm)	Males	200	21.37	0.63	0.04	0.18	2.291	0.02*
	Females	200	21.18	0.95	0.07			
UCPM (in mm)	Males	200	21.89	0.89	0.06	0.07	0.777	0.44
	Females	200	21.82	0.90	0.06			

[Table/Fig-3]: Gender-wise comparison of mean study parameters using Student t-test.
* Statistically significant; Note: LI – Combined mesiodistal width of Lower Incisors. LCPM-Lower canines premolars, UCPM-Upper canine premolars.

Further, the gender based linear regression analysis were conducted to provide separate prediction equations for maxillary and mandibular arches, and the relevant coefficients of correlation for the canine-premolar segments of each dental arch, the values of "a" and "b" for the two regression equations and the standard error of estimate are summarized in [Table/Fig-4]. New regression equations for local population are presented in [Table/Fig-5].

A prediction model was proposed estimating the canine premolar width for males and females in the upper and lower arches separately considering for varying measurements of combined mesiodistal width of lower incisors is presented in [Table/Fig-6].

Variable	X	Gender	Constant (a)	p-value (a)	Constant (b)	p-value (b)	r^2	SEE	r
UCPM	LI	Male	16.904	<0.001*	0.209	<0.001*	0.254	0.773	0.504
UCPM	LI	Female	15.627	<0.001*	0.263	<0.001*	0.175	0.821	0.419
LCPM	LI	Male	17.204	<0.001*	0.174	<0.001*	0.352	0.511	0.593
LCPM	LI	Female	13.431	<0.001*	0.330	<0.001*	0.247	0.827	0.497

[Table/Fig-4]: Predicted Values for estimation of canine and premolar width for Bengaluru population children are tabulated.
*Statistically Significant
Linear Regression Analysis was performed to obtain regression equations of the form Y=a+b(x) to be used clinically for the prediction of tooth size in a similar Indian population. The standard error of the predicted maxillary and mandibular values for each value of the sum of the mandibular incisors was also calculated. LCPM-Lower canines premolars, UCPM-Upper canine premolars

Arch	Sex	Equation	r	p-value
Maxillary	Male	Y = 16.90 + 0.21 * (x)	0.504	<0.001*
	Female	Y = 15.63 + 0.26 * (x)	0.419	<0.001*
Mandibular	Male	Y = 17.20 + 0.17 * (x)	0.593	<0.001*
	Female	Y = 13.43 + 0.33 * (x)	0.497	<0.001*

[Table/Fig-5]: New regression equations of canine and premolar width were derived for both males and females of Bangalore population and are tabulated below.
*Statistically Significant
Note: Y-Canine premolar width to be estimated; x-Combined mesiodistal width of lower incisors. Linear Regression Analysis was performed to obtain separate regression equations for males and females.

LI (in mm)	Male		Female	
	Upper	Lower	Upper	Lower
19	20.89	20.43	20.57	19.70
19.5	21.00	20.52	20.70	19.87
20	21.10	20.60	20.83	20.03
20.5	21.21	20.69	20.96	20.20
21	21.31	20.77	21.09	20.36
21.5	21.42	20.86	21.22	20.53
22	21.52	20.94	21.35	20.69
22.5	21.63	21.03	21.48	20.86
23	21.73	21.11	21.61	21.02
23.5	21.84	21.20	21.74	21.19
24	21.94	21.28	21.87	21.35
24.5	22.05	21.37	22.00	21.52
25	22.15	21.45	22.13	21.68
25.5	22.26	21.54	22.26	21.85
26	22.36	21.62	22.39	22.01
26.5	22.47	21.71	22.52	22.18
27	22.57	21.79	22.65	22.34
27.5	22.68	21.88	22.78	22.51
28	22.78	21.96	22.91	22.67
28.5	22.89	22.05	23.04	22.84
29	22.99	22.13	23.17	23.00

[Table/Fig-6]: Predicted mesiodistal widths of canines and premolars for Bengaluru population children are tabulated.
Note: LI – Combined mesiodistal width of lower incisors

DISCUSSION

The present study was done to determine the mesiodistal width of canines and premolars and to check the applicability of Tanaka Johnston method on local ethnic Kannada speaking population. Sample size to the number of 400 was taken, aged between 13 to 16 years. This was a cross-sectional study that assessed the tooth size correlation between lower incisors and the posterior segments.

Multiple regression analyses have indicated that the sum of the mesiodistal width of the four mandibular permanent incisors is the best predictors for unerupted canines and premolars [5,9,10], because these are the teeth that are the first to erupt during the early mixed dentition. The present study showed a fair correlation between the mesiodistal width of erupted mandibular incisors and mesiodistal width of erupted canines and premolars.

The Tanaka Johnston method of space analysis is most commonly used method in mixed dentition [14]. Tanaka Jhonston method in its original form cannot be applied for local population, so there is a need to derived new regression equations for local population so that it could be used routinely to predict the space require for unerupted teeth.

In the present study, statistically significant differences were seen when comparing the estimated and measured canines and premolars widths. Tanaka Johnston analysis significantly over estimated the actual mesiodistal widths of maxillary and mandibular canines and premolars in both males and females of local Bangalore population. The results of this study were in accordance with studies done in India by Chandna A et al., and Sonawane S and Bettigiri A [15,16]. Similarly, Tanaka and Johnston analysis overestimated the actual mesiodistal widths of canines and premolars in various populations [17-20].

In mixed dentition prediction of the mesiodistal dimensions of unerupted permanent canines and premolars is of clinical importance in diagnosis and treatment planning. Accurate estimation of the size of canines and premolars allows the dentist to better manage tooth size/arch length discrepancies.

Studies have demonstrated that the mesiodistal tooth dimensions are gene determined to a large extent. Environmental variables such as nutrition, disease and climate, affect the dentition during the prenatal period but seem to have little influence on normal dental variation [21].

Sexual dimorphism was evident in the mesiodistal tooth dimensions of males and females for central incisors, canines, and premolars. The results of present study demonstrated a statistically significant difference in the LCPM width between the genders, with males having a significantly higher width than females. A borderline significance was observed with respect to the combined mesiodistal width of Incisors, with males having an increased width than females. However, the UCPM width did not differ significantly between the genders.

This sexual dimorphism has been seen in various studies [22-24]. Division of subjects according to sex when performing mixed dentition analysis was therefore necessary.

Definite racial and ethnic differences in tooth size have been emphasized in several studies [23,25,26]. This has been demonstrated in the present study by significant amount of differences between the mean values of actual mesiodistal widths of permanent canines and premolars and those derived from Tanaka Johnston's method.

The results obtained could be different due to the differences in the ethnic origins of the samples, as Asiry MA et al., also found different results when applying the Tanaka Johnston method to the Saudi Arab population [27]. Similar findings were found in various studies carried out in India for various populations [5,28-32]. The research till date and as well as the present study, supports that racial differences are to be important variables in tooth size prediction equations.

Since the literature is lacking in the formulation of such regression equation for its own population, the present study attempted to formulate regression equations for the children of Bangalore population.

Tanaka Johnston method cannot be used accurately to estimate the combined mesiodistal widths of unerupted permanent canines and premolars in every population group.

Based on this information, there is a need to determine new regression equations and constants which are applicable for our population. So after deriving the values of the constants "a" and "b", new regression equations were also determined. New regression equations for our sample populations are tabulated in [Table/Fig-5].

Regression equations vary for different racial and ethnic groups so a new prediction chart for local population derived for males and females separately using new regression equations are presented in [Table/Fig-6].

Different population showed difference in mesiodistal widths of erupting canines and premolars, so there was need for deriving new regression equations for this population. The present study also derived new regression equations for the population. Different regression equations developed for various populations are tabulated in [Table/Fig-7].

SL No	Population	Regression equations	
		Males	Females
1	Saudi [27]	Max:Y=10.3+0.49 (X)	Y=11.7+0.39(X)
		Mand: Y=9.7+0.49(X)	Y=11.3+0.39(X)
2	Thai [23]	Max:Y=13.36+0.41(X)	Y=11.16+0.49(X)
		Mand:Y=11.92+0.43(X)	Y=9.49+0.53(X)
3	Western UP [29]	Max:Y=9.6+0.40(X)	Y=9.4+0.37(X)
		Mand:Y=9.3+0.42(X)	Y=8.9+0.46(X)
4	Belgaum [31]	Max:Y=10.52+0.48(X)	Max:Y=11.73+0.41(X)
		Mand: Y=9.46+0.50(X)	Mand:Y=11.67+0.39(X)
5	Nalgonda [32]	Max:Y=11.0+0.50(X)	Max:Y=11.1+0.495(X)
		Mand:Y=10.4+0.50(X)	Mand:Y=10.4+0.502(X)
6	Present Study	Max: Y=16.90+0.21(X)	Y=15.63+0.26(X)
		Mand: Y=17.20+0.17(X)	Y=13.43+0.33(X)

[Table/Fig-7]: Various regression equations derived for different populations.

LIMITATION

The present study has considered the samples derived from Bangalore city, and it needs to obtain similar validation on rural and other mixed Indian population. Hence, the investigator recommends conducting a similar study with a larger sample size to cross validate the present study findings using newly derived equations.

CONCLUSION

Tanaka Johnston prediction method originally used for Northern European descent is not accurate when applied to a population of local ethnic groups of India that over estimated for Bangalore population. So, new regression equations have been formulated for local Bangalore population to predict the space required for alignment of unerupted canines and premolars in both males and females to help the clinician to reduce time in planning and management of cases.

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