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Reliability of Moyers and Tanaka Johnston Mixed Dentition analysis in school children of Belgaum

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Abstract

Context: The accuracy of Moyers proportionality tables and Tanaka and Johnston equations are fairly good when applied to children from northern European descents from which data were originally obtained. Because racial difference in mesiodistal tooth width is said to exist it is logical to doubt their applicability in other population.

Aims: The purpose of this study are to test the reliability of Moyers mixed dentition analysis and Tanaka Johnston equations in Belgaum population, so as to aid in treatment planning for the orthodontists in this region.

Methods and Material: A cross-sectional study comprising hundred subjects of Belgaum population who met our criteria (ages, 14-16 years; 50 boys, 50 girls) were selected from local schools. Mesiodistal dimensions of permanent mandibular incisors, maxillary and mandibular canines, and premolars were measured using a digital caliper with a resolution of 0.01 mm.

Statistical analysis: Students unpaired "t" test was used to compare the sex differences between the groups of teeth. Correlation and regression analysis were performed and standard regression equations for both sexes combined and for males and females separately were developed.

Results: Moyers probability table at 75% and Tanaka-Johnston equations overestimates the actual measurements in this population. Highly significant correlations were found between the mandibular incisors and the combined mesiodistal widths of the canines and premolars for the maxillary (r=0.37; P=0.00001) and mandibular (r=0.46; P=0.00001) segments.

Conclusions: Tanaka and Johnston and Moyers prediction methods were not accurate when applied to Belgaum population as it tends to overestimate the actual measurements. Due to their inadequacy new prediction tables & equations were formulated specifically for Belgaum population.

Keywords: Mixed dentition analysis, Prediction equations, Belgaum population.

Introduction

As the number of patients demanding early orthodontic treatment continues to rise, it is imperative that the mixed dentition space analysis is accurately done before orthodontic treatment is offered.[(1)] The prediction of unerupted canine & premolar size in the patient with mixed dentition is central to early orthodontic diagnosis & treatment.[(2)] Early attempts at estimation were based on tables of average widths, for example those of Black,[(3)] & they were seldom appropriate for the individual. The concept of dental space analysis is not a recent idea. Review of the literature indicates attempts to predict the width of the un-erupted permanent canines and premolars were published in the early 1900's and can be categorized into three basic methods:

1) Direct measurement on radiograph.[(2,4,5,6)]
2) Calculations for prediction equations and tables.[(7-12)]
3) Combination of radiographic measurements and prediction tables.[(13-17)]

The accuracy of radiographic prediction methods is largely influenced by the quality of the radiograph and the technique with which the films are taken; underexposure / overexposure / distortions etc of x-rays are certain disadvantages. Also, high quality films and a meticulous radiographic technique are essential for minimal error. Even if these variables are controlled, the teeth can be rotated in their crypts, giving false measurements.[(18)] Hence these disadvantages can only be overcome with prediction tables or equations. As it is known that the commonly used Moyers prediction tables and Tanaka-Johnston equations were developed for white North American children, their applicability in other populations is questionable because tooth sizes differ in various racial groups.

Objectives of the study

1. To test the reliability of Moyers and Tanaka Johnston mixed dentition analysis in Belgaum population.
2. To construct probability tables for Belgaum population if Moyers probability tables were not reliable.
3. To formulate prediction equations for Belgaum population if Tanaka-Johnston's prediction equations were not reliable.

Subjects and Methods

The subjects for this cross-sectional study were selected from 8 schools (multilingual media) representing different socioeconomic strata, located in Belgaum, Karnataka. Approval from the college ethical review committee & the Principals of respective schools was obtained. Additionally consent was obtained from the students & their parents for dental examinations and

for possible selection for subsequent dental impressions. Students were called in groups from their classrooms to a specially equipped room where the clinical examination & screening was conducted. After we examined around 1000 school children in the range of 14-16 years, we selected a sample of 100 (50 boys, 50 girls) who met our study criteria. Inclusion criteria were native of Belgaum; all permanent teeth present in each arch (fully erupted with the exception of the second and third molars)[19,20] Class I molar and canine relationships and minor malocclusions such as minimal incisor crowding or spacing. The exclusion criteria were subjects with congenital craniofacial anomalies[19,20] or previous orthodontic treatment, and teeth with fractures, malformations, proximal caries, restoration, or significant attrition.[21-24]

Dental impression were taken with alginate impression material (Tropicalgin) and immediately poured with dental stone (Goldstone Class III) to avoid any dimensional change. Mesiodistal dimension of permanent mandibular incisors and maxillary and mandibular canines and premolars were measured using digital caliper with resolution of 0.01 mm[25] (Fig. 1). The tips of the calipers were precision engineered to facilitate degree of accuracy. The mesiodistal dimensions of the teeth were obtained by measuring the maximum distance between approximate surfaces of the teeth.

Values obtained from the right and left posterior segments were averaged so that there would be one value for the maxillary canine and premolars and one value for the mandibular canine and premolars. For measurement reliability, teeth were measured manually and independently by two investigators. The two measurements obtained were compared and if they varied by 0.2 mm or less, the values were averaged.[25] In instances where the measurements varied by more than 0.2 mm, the teeth were re measured and the nearest 2 measurements were averaged.

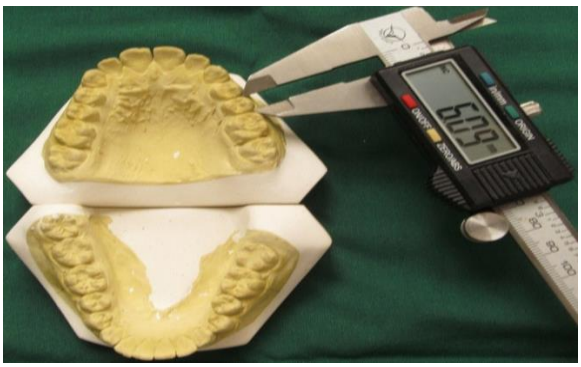


Fig.1: Digital caliper used to measure tooth dimension on study model with resolution of 0.01 mm (make-Aerospace)

Results

Descriptive statistics including mean, SD, SE, t-value and p-value by student's "t" test for mean combined mesiodistal width of lower incisors, Upper canine premolars, and Lower canine premolars for male and female individuals are presented in Table 1 & Graph 1 for males & females separately. The sum of permanent canines & premolars in the maxillary arch between males & females (p=0.00001) was statistically significant with larger combined mesiodistal width in males compared to females. In mandibular arch, the sum of mesiodistal widths of canine & premolars between males & females showed differences but were not statistically significant (p=0.08). The differences between the sum of mesiodistal width of mandibular incisors also were statistically insignificant (p=0.447).

Coefficient of correlation for canine and premolar segments of each dental arch, & the regression values of a&b in the standard linear regression equation, Y=a+bx, and the standard errors of the estimates (SEE) and coefficient of determination (r^2) of the maxillary and mandibular regression are shown in (Table 2), for sexes combined, and for males and females separately.

The measured values of sum of four permanent lower incisors, sum of widths of permanent maxillary and mandibular canines, first and second premolars were subjected to correlation and regression analysis and prediction equations were formulated for males and females separately and for combined groups as under,

Males: Maxillary, Y = 16.65 + 0.17 (X)
Mandibular, Y = 12.93+ 0.33 (X)
Females: Maxillary, Y = 10.62+ 0.38 (X)
Mandibular, Y = 11.11+ 0.39 (X)
Combined: Maxillary, Y = 12.63 + 0.32 (X)
Mandibular, Y = 11.81+ 0.37 (X)

The prediction table generated from these equations is given in (Table 3 & 4).

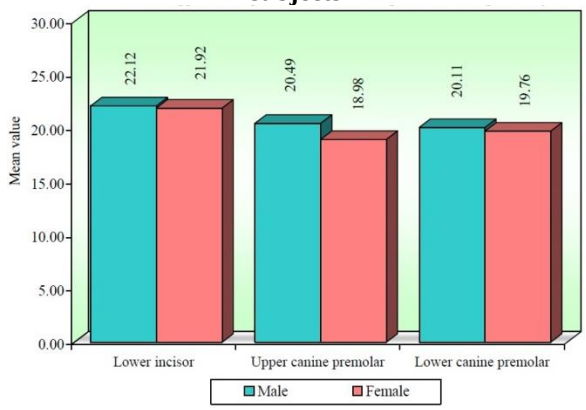
Comparison of Tanaka- Johnston and Moyers predicted values at 75% with the present study predicted values at 75% (Graph 2-5); shows that both in maxillary & mandibular arch the predicted values by Moyers & Tanaka Johnston overestimated the predicted values.

Table 1: Descriptive statistics including, mean, SD, SE, t-value and p-value by student's t test for mean combined mesiodistal width of LI, UCPM, and LCPM for male and female individuals.

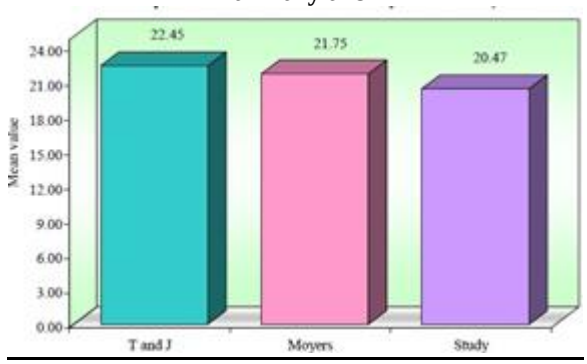
Variables	Sex	n	Mean	SD	SE	t-value	p-value
Lower incisor	Male	50	22.12	1.30	0.18	0.7632	0.4472*
	Female	50	21.92	1.33	0.19		
Upper canine pre molar	Male	50	20.49	0.79	0.11	8.6197	0.00001***
	Female	50	21.92	1.33	0.19		
Lower canine pre molar	Male	50	20.11	0.97	0.14	1.7153	0.0895*
	Female	50	19.76	1.10	0.16		

*Not significant, ***Highly significant, n=number of individuals, SD=Standard deviation, SE=Standard error, LI= Sum of Lower incisor, UCPM=combined mesiodistal width of Upper canine premolar segment, LCPM=combined mesiodistal width of Lower canine premolar segment.

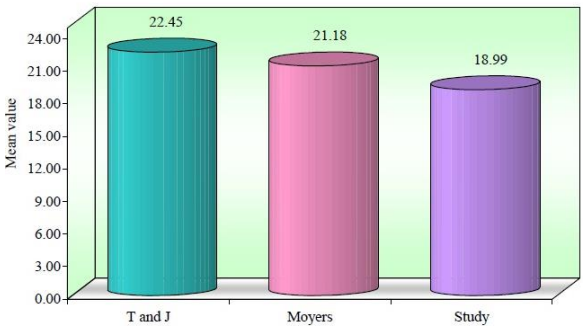
Graph 1: Gender comparison of the mean combined mesiodistal widths of lower incisors, upper canine premolar, lower canine premolar, of Belgaum subjects



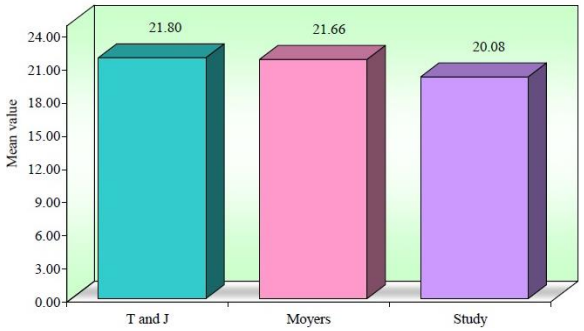
Graph 2: Comparison of Tanaka- Johnston and Moyers predicted values at 75% with the present study predicted values at 75% for male subjects in maxillary arch



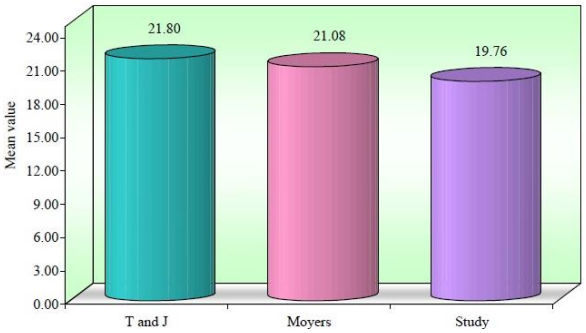
Graph 3: Comparison of Tanaka- Johnston and Moyers predicted values at 75% with the present study predicted values at 75% for male subjects in maxillary arch for female subjects in maxillary arch



Graph 4: Comparison of Tanaka- Johnston and Moyers predicted values at 75% with the present study predicted values at 75% for male subjects in maxillary arch for male subjects in mandibular arch



Graph 5: Comparison of Tanaka- Johnston and Moyers predicted values at 75% with the present study predicted values at 75% for male subjects in maxillary arch for female subjects in mandibular arch



Discussion

Tooth & facial characteristics differ among populations of different racial or ethnic origin. Most used methods to predict widths of unerupted permanent teeth were developed for Caucasian population. Studies to confirm their effectiveness & applicability in different populations are appropriate. The presence of sexual dimorphism has been indicated in previous studies.[1] Definite racial and ethnic difference in tooth sizes has been emphasized in most of the studies. Several odontometric studies have found that mesiodistal tooth widths to be larger in black populations than in Caucasians.[26,27]

The racial & ethnic differences in tooth sizes of various studies[18,22,28,29] have shown that black South Africans have the largest teeth of all groups for both sexes. The present sample tend to have smaller combined mesiodistal tooth widths in both sexes. Therefore the prediction techniques based on single racial sample may not be considered universal.

The correlation coefficient (r) of the present study ranged from 0.28 - 0.54 (Table 2) with increased correlation for female subjects in the maxillary & mandibular arch and lower correlation coefficient for male subjects in the maxillary & mandibular arch. The regression coefficients calculated in the present study slightly differed from those published by Tanaka and Johnston.[2]

The incisor–buccal segment correlations that were found here (0.37 & 0.46, Table 2) demonstrated a lower correlation compared to Tanaka –Johnston (0.62 & 0.65).[2] The correlation coefficients obtained for the Belgaum population, between the buccal segments of each arch were found to be smaller than for Hong Kong Chinese,[28] Thai population,[22] black Senegalese girls[23] & Pakistani sample in both the sexes. Differences in coefficient values between the various ethnic studies illustrate tooth size variability between different ethnic groups. However, it is quite clear from the results of most odontometric studies (Kaplan et al;[30] Ingerval and Lennarston;[31] Gardner[32]) that sex dimorphism does exist in mesiodistal widths of permanent teeth.

The coefficients of determination (r^2) in Table 2 are indicators of predictive accuracy of the regression equations for Y (the sum of mesiodistal widths of canine & premolars) based on values of X (the corresponding sum of mesiodistal widths of four mandibular incisors). This coefficient represents the proportion (often expressed as a percentage) of the total variance of Y, which is determined by the X value of each regression equation.[22] From data for sexes pooled, in the present study (Table 2), the coefficients of determination (r^2) show 0.14 for the maxillary teeth & 0.21 for the mandibular teeth. Therefore, 14 & 21 percent of the total variances for the sum of maxillary & mandibular canine & premolar summations, respectively, are accounted for by knowing the sum of the mandibular widths. Females show higher r^2 values (0.29 for the maxillary teeth & 0.23 for the mandibular teeth) than males. Among the various studies that has been done Yuen et al[28] in Hong Kong Chinese shows higher (r^2) values. The differences in error variance between the sets of r^2 of the above shown studies might be attributable to the effects of different sample sizes & ethnic mixes.

The error involved in the use of prediction equations is indicated by the SEE (Table 2) the lower the SEE, the better the prediction equation. The values obtained from this study were comparable with Thai,[22] with values ranging from 0.77 to 0.98. The SEE in the present study is higher for females compared to males.

Table 2: Regression parameters of Canine premolar segment of maxillary & mandibular arch to sum of lower incisors

Canine premolar segment	Sex	Correlation coefficient (r)	Coefficient of determination (r^2)	Regression Analysis			p-value
				Constant (a)	Estimates (b)	Standard error of estimates (SEE)	
Maxillary arch	Male	0.28	0.08	16.65	0.17	0.77	0.0454**
	Female	0.54	0.29	10.62	0.38	0.81	0.00001***
	Total	0.37	0.14	12.63	0.32	1.08	0.00001***
Mandibular arch	Male	0.43	0.19	12.93	0.33	0.88	0.0016**
	Female	0.48	0.23	11.11	0.39	0.98	0.0004**
	Total	0.46	0.21	11.81	0.37	0.93	0.00001***

** Significant, ***Highly significant

Observation of regression parameters from different studies[18,22,28,29] when compared with the present study showed lower B values of 0.32 in maxilla & 0.37 in mandible with that of Thai,[22] Hong Kong Chinese,[28] and Pakistani population.[18] Constant A values of 12.63 for maxillary teeth & 11.81 for mandibular teeth in our sample appeared to be similar with those of Thai population.[22]

Therefore based on the results obtained from this study & the comparison with other studies, it is appropriate to say that Moyers 75% tends to overestimate when used in this population. This study reveals that the Moyers charts at the 75% percentile confidence level overestimates the size of the buccal segment in Belgaum population (Graphs2-5). The proposed new probability tables prepared for male and female Belgaum population as presented in (Table 3 and 4), demonstrates the inadequacy of Moyers. For males, Moyers 65th percentile in the upper arch and the 35th percentile in the lower arch; and for females, the 15th percentile in the upper arch and 35th percentile in the lower arch predicted the sum of widths of permanent canine and premolars more precisely than the commonly used 75th percentile as recommended by Moyers. The prediction table is convenient to use and does not require memorizing equations. While Tanaka –Johnston equations proved to be inaccurate due to which new prediction equations were formulated specifically for Belgaum population. The use of these equations is simple, easy and relatively accurate for predicting the mesiodistal width of un-erupted teeth in this specific population.

Table 3: Prediction tables for maxillary canine and premolars in terms of incisors

Samples	Percentiles	20.00	21.00	22.00	23.00	24.00	25.00
Males	95	20.00	21.00	20.54	20.70	20.84	20.86
	90	20.00	20.37	20.53	20.65	20.78	20.79
	75	20.13	20.34	20.46	20.57	20.65	20.65
	50	20.11	20.24	20.36	20.44	20.51	20.52
	25	20.06	20.13	20.22	20.26	20.34	20.34
	10	20.04	20.07	20.11	20.13	20.14	20.14
	5	20.04	20.04	20.06	20.08	20.09	20.10
Females	95	20.00	18.81	19.16	19.52	19.74	19.85
	90	20.00	18.75	19.05	19.49	19.62	19.69
	75	18.42	18.68	18.88	19.23	19.35	19.35
	50	18.34	18.60	18.67	18.83	18.88	18.95
	25	18.23	18.39	18.43	18.59	18.63	18.63
	10	17.81	18.23	18.30	18.34	18.36	18.36
	5	17.81	17.87	18.07	18.23	18.25	18.25

Table 4: Prediction tables for mandibular canine and premolars in terms of incisors

Samples	Percentiles	20.00	21.00	22.00	23.00	24.00	25.00
Males	95	20.00	20.00	20.21	20.50	20.77	20.81
	90	20.00	19.88	20.19	20.41	20.65	20.67
	75	19.48	19.84	20.06	20.25	20.41	20.42
	50	19.41	19.65	19.87	20.02	20.15	20.17
	25	19.33	19.44	19.61	19.68	19.83	19.84
	10	19.28	19.33	19.39	19.44	19.45	19.46
	5	19.28	19.28	19.31	19.35	19.37	19.37
Females	95	20.00	19.58	19.94	20.31	20.55	20.66
	90	20.00	19.52	19.83	20.28	20.41	20.49
	75	19.18	19.44	19.65	20.01	20.14	20.14
	50	19.11	19.36	19.44	19.60	19.65	19.72
	25	19.00	19.15	19.19	19.35	19.39	19.40
	10	18.54	18.98	19.05	19.09	19.11	19.12
	5	18.54	18.61	18.81	18.98	19.00	19.00

Conclusion

1. The commonly used Moyers (75%) prediction methods were not accurate when applied to our sample of Belgaum population since it tends to overestimate the actual measurements.
2. For males, Moyers 65th percentile in the upper arch and the 35th percentile in the lower arch; and for females, the 15th percentile in the upper arch and 35th percentile in the lower arch predicted the sum of widths of permanent canine and premolars more precisely than the commonly used 75th percentile as recommended by Moyers.
3. Due to the inadequacy of Moyers prediction tables, new prediction tables were formulated for Belgaum population.
4. Due to over prediction of Tanaka-Johnston equations, new prediction equations were formulated specifically for Belgaum population. The use of these equations is simple, easy and relatively accurate method for predicting the mesiodistal width of un-erupted teeth in this specific population: Maxillary, Y = 12.63 + 0.32 (X), Mandibular, Y = 11.81+ 0.37 (X).

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