Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Special Issue [1]2022 : 1393-1399

Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
ORIGINAL ARTICLE **OPEN ACCESS**

Evaluation and Applicability of Tanaka and Johnston and Moyers Mixed Dentition Space Analysis in a Population of Durg Chhattisgarh

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ABSTRACT
In orthodontics most of cases, malocclusion start during mixed dentition stage. Earlier diagnosis and management of developing malocclusion help to resolve the problem effectively. Mixed Dentition Analysis helps one estimate the amount of spacing or crowding which would exist for the patient if all the primary teeth were replaced by their successors. The purpose of the study was done to evaluate the applicability of Tanaka–Johnston and Moyer's mixed dentition analysis in the prediction of mesiodistal width of unerupted canines and premolars for Chhattisgarh population. Study conducted on a sample of 50 children with age group of 13 to 16 years who had all permanent teeth that were fully erupted. Dental impressions were taken with alginate impression material and immediately poured with dental stone. Mesiodistal dimensions of permanent mandibular incisors, maxillary and mandibular canines, and premolars were measured using a digital calliper. Tanaka and Johnston prediction equations underestimated mesiodistal widths of permanent canines and premolars in Durg population. Moyers 75th percentile also overestimated actual measurements for mandibular arch in male subjects and maxillary arch in female. From our study, we have developed the following new regression equations for Durg Chhattisgarh to predict tooth width of unerupted teeth.
Male: Maxilla: $Y = 7.77 + 0.73x$ Mandible: $Y = 10.95 + 0.61x$
Female: Maxilla: $Y = 7.43 + 0.64x$ Mandible: $Y = 9.54 + 0.59x$
Regression equations and probability tables derived for tooth size prediction for Chhattisgarh population would be more accurate when applied locally.Tanaka–Johnston equations underestimated the values therefore less appropriate to be used in this population. However, Moyer's prediction tables can be used but at different probability levels for both genders.
Keywords: *Mixed dentition analysis, Prediction equations, Durg population*

Received 11.02.2022 Revised 19.03.2022 Accepted 30.04.2022

INTRODUCTION

As a number of patients demanding early orthodontic treatment continues to rise it is imperative that the mixed dentition space analysis is accurately done .Orthodontic problems in a child with good facial proportions involve crowding, irregularity, or malposition of the teeth. At this stage, regardless of whether crowding is apparent, the results of space analysis are essential for planning treatment [1].
The purpose of a Mixed Dentition Analysis is to evaluate the amount of space available in the arch for succeeding permanent teeth and necessary occlusal adjustments. The Mixed Dentition Analysis helps one estimate the amount of spacing or crowding which would exist for the patient fall the primary teeth were replaced by their successors the very day the analysis is done, not 2 or 3 years later [2].
The prediction of unerupted canine and premolar size in the patient with mixed dentition is central to early orthodontic diagnosis and treatment. Concept of dental space analysis to predict the width of unerupted permanent canine and premolars developed in the early 1900's. typically mesiodistal dimensions of unerupted canine and premolar have been next rapolated from measurement from erupted mandibular incisors using Tanaka & Johnston[3]predictionequations or Moyer's probability tables [3].
The genetic fields within which permanent tooth size is controlled extend to involve a number of teeth,

therefore, people with large teeth in one part of the mouth tend to have large teeth elsewhere. A number of researchers have studied the correlative relationships between groups of teeth in the permanent dentition, very high correlations exist between left-right groups of teeth in the same arch and there is a decreasing correlation gradient, generally from front to back within an arch. The accurate width of an unerupted tooth is important for correct diagnosis of a case. Neither over estimation nor underestimation of width should be done for accurate treatment plan [4].

Numerous methods of predicting the mesiodistal widths of unerupted canines and premolars have been reported. These methods use three distinct ways to achieve the purpose. The first employs direct measurements of the teeth from radiographs with or without the use of prediction formula [4-6]. The second method utilizes prediction tables based on measurements of other erupted permanent teeth [2-8]. The third method involves a combination of previous two methods,i.e.,the use of prediction tables in association with measurements of erupted and unerupted teeth [6-11]. However, radiographic methods are not usually carried out be can use they are time consuming and the correlation coefficients between the real sizes of "reference teeth "and the “real values "of predicted teeth are not high enough to ensure good prediction [12].

The accuracy of radiographic prediction methods is largely influenced by the quality of the radiograph and the technique with which the films retaken; 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 [13]. Hence these disadvantages can only be overcome with prediction tables or equations. As it is known that the commonly used Moyer’s 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 [14-16]. Anthropological studies reveal that tooth size varies among different races an dethnicities. So, there is a need for studying such racial trends and verifying the authenticity of standard prediction tables in different populations.

The present study was conducted with an aim of evaluation and applicability of Tanaka &Johnston and Moyer’s mixed dentition space analysis in a population of Durg Chhattisgarh. At the same time, new prediction equations were also formulated with an objective to provide an accurate mixed dentition analysis among population of Durg Chhattisgarh.

MATERIAL AND METHODS

It’s a cross sectional study conducted over a period of four months using study models. Dental study models of 50 subjects (25 males & 25 females) were collected from patients visiting MCDRC Durg Chhattisgarh.

The criteria for selection were based on the following:

1. Patients had to be resident of Durg Chhattisgarh and aged between13to 16years.
2. The dental casts had to be of high quality.
3. The teeth measured had to be free of malformations, restorations, absence of any previous orthodontic treatment, fractures, or caries as determined by radiographic examination.
4. All permanent teeth with the exception of second and third molars should be present and fully erupted.

Fig.1:Digital calliper used to measure tooth dimension on study model with resolution of 0.01mm

Orthodontic study models were made by using alginate impression and poured in dental stone immediately. All measurements were taken directly from unsoaped plaster study models. Teeth measured included mandibular permanent central and lateral incisors, maxillary and mandibular permanent canines, first and second premolars. Mesio-distal measurement was done using digital calliper (figure 1) and values obtained for right and left segments were averaged so that we obtained single mesio-distal width for maxillary and mandibular permanent canines, first and second premolars.

RESULTS

In our samples, Moyer's probability chart was not an accurate method to predict tooth dimension. Table 1 shows descriptive statistics of measurements obtained from sample population of Chhattisgarh indicates the mean and standard deviation values for selected teeth. Table 2 indicates the coefficient of correlation (r), regression constants (a, b), and coefficient of determination (r^2) for various tooth groups in different groups of participants. The r and r^2 in our study is 0.57 and 0.25, respectively. Table 3 shows comparison of actual and predictive values using unpaired' test. Tables 4-7 are the prediction tables of Moyer's at 75th, 50th, and35th percentile along with the present 75th percentile prediction for the Durg Chhattisgarh for both genders. Moyers 75th percentile also overestimated actual measurements for mandibular arch in male subjects and maxillary arch in female.

From our study, we have developed the following new regression equations for the Durg Chhattisgarh to predict tooth width of unerupted teeth

Male Maxilla:

Y = 7.77 + 0.73x Mandible:

Y = 10.95 + 0.61xFemale:Maxilla:Y =7.43+0.64xMandible:Y= 9.54+0.59x

Table 1: Descriptive statistics of measurements obtained from sample population of Durg Chhattisgarh

Males	Mean	SD	SE	Minimum	Maximum
Lower incisor width (LI)	**24.49**	**1.47**	**0.29**	**21.3**	**27.6**
Upper CPM (UCPM)	**22.79**	**1.19**	**0.23**	**20.6**	**24.65**
Lower CPM (LCPM)	**21.95**	**1.34**	**0.26**	**19.15**	**24.05**

Table2: Regression parameters of Canine premolar segment of maxillary & mandibular archtosum of lower incisors

Females	Mean	SD	SE	Minimum	Maximum
Lower incisor width (LI)	**23.97**	**0.85**	**0.17**	**22.4**	**25.4**
Upper CPM (UCPM)	**22.21**	**0.86**	**0.172**	**20.55**	**23.85**
Lower CPM (LCPM)	**21.34**	**0.92**	**0.185**	**19.15**	**22.6**

Males	r	a	b	r2	Std. error of estimate
UCPM	**0.643**	**7.77**	**0.73**	**0.401**	**0.943**
LCPM	**0.596**	**10.95**	**0.61**	**0.341**	**0.989**

Females	r	a	b	r2	Std. error of estimate
UCPM	**0.732**	**7.43**	**0.64**	**0.492**	**0.962**
LCPM	**0.785**	**9.54**	**0.59**	**0.445**	**0.995**

Male Maxilla:

Y = 7.77 + 0.73x Mandible: Y = 10.95 + 0.61x

Female: Maxilla:

Y =7.43+0.64xMandible: Y= 9.54+0.59x

These are there regression equations for Durg Chhattisgarh population.

Table3: Comparison of actual and predictive values using student't'test

Gender	Arch	75th Percentile		50th Percentile		35th Percentile	
		t test	**p value**	**t test**	**p value**	**t test**	**p value**
Male	**Maxillary**	**t = 6.954**	**p<0.001****	**t = 8.178**	**p<0.001****	**t = 9.023**	**p<0.001****
	Mandibular	**t =9.812**	**p<0.001****	**t = 11.83**	**p<0.001****	**t = 13.47**	**p<0.001****
Female	**Maxillary**	**t =15.84**	**p<0.001****	**t =14.65**	**p<0.001****	**t =18.46**	**p<0.001****
	Mandibular	**t = 11.37**	**p<0.001****	**t = 12.65**	**p<0.001****	**t = 15.32**	**p<0.001****

Table 4: Prediction table for maxillary chart in males with Moyer's probability chart

L*	75thPercentile	50thPercentile	35thPercentile	Present75th
19.5	20.3	19.7	19.3	22.0
20.0	20.5	19.9	19.6	22.4
20.5	20.8	20.2	19.9	22.7
21.0	21.0	20.4	20.1	23.1
21.5	21.3	20.7	20.4	23.5
22	21.5	20.9	20.6	23.8
22.5	21.8	21.2	20.9	24.2
23	22	21.5	21.1	24.6
23.5	22.3	21.7	21.4	24.9
24	22.5	22	21.6	25.3
24.5	22.8	22.2	21.9	25.7
25	23	22.5	22.1	26.0
25.5	23.3	22.7	22.4	26.4

L*=Sum of mandibular incisors.

Table5: Prediction table for mandibular chart in males with Moyer's probability chart

L*	75th Percentile	50th Percentile	35th Percentile	Present75th
19.5	20.4	19.5	19.0	19.91
20.0	20.6	19.7	19.3	20.23
20.5	20.8	20.0	19.5	20.55
21.0	21.0	20.2	19.7	20.87
21.5	21.2	20.4	20.0	21.19
22	21.4	20.6	20.2	21.51
22.5	21.6	20.9	20.4	21.83
23	21.9	21.1	20.6	22.15
23.5	22.1	21.3	20.9	22.47
24	22.3	21.5	21.1	22.79
24.5	22.5	21.7	21.3	23.11
25	22.8	22.0	21.5	23.43
25.5	23.0	22.2	21.7	23.75

L*=Sum of mandibular incisors

Table6:Prediction table for maxillary chart in females with Moyer's probability chart

L*	75thPercentile	50thPercentile	35thPercentile	Present75th
19.5	20.4	19.6	19.2	19.91
20.0	20.5	19.8	19.4	20.23
20.5	20.6	19.9	19.5	20.55
21.0	20.8	20.1	19.7	20.87
21.5	20.9	20.2	19.8	21.19
22	21.0	20.3	19.9	21.51
22.5	21.2	20.5	20.1	21.83
23	21.3	20.6	20.2	22.15
23.5	21.5	20.8	20.4	22.47
24	21.6	20.9	20.5	22.79
24.5	21.8	21.0	20.6	23.11
25	21.9	21.2	20.8	23.43
25.5	22.1	21.3	20.9	23.75

L*=Sum of mandibular incisors

Table7:Prediction table for mandibular chart in females with Moyer's probability chart

L*	75thPercentile	50thPercentile	35thPercentile	Present75th
19.5	19.6	18.7	18.2	21.045
20.0	19.8	19.0	18.5	21.34
20.5	20.1	19.2	18.8	21.635
21.0	20.3	19.5	19.0	21.93
21.5	20.6	19.8	19.3	22.225
22	20.8	20.0	19.6	22.52
22.5	21.1	20.3	19.8	22.815
23	21.3	20.5	20.1	23.11
23.5	21.6	20.8	20.3	23.405
24	21.9	21.1	20.6	23.7
24.5	22.1	21.3	20.9	23.995
25	22.4	21.6	21.1	24.29
25.5	22.7	21.8	21.4	24.585

L*=Sum of mandibular incisors

DISCUSSION

As early treatment is becoming increasingly critical in orthodontics, Mixed dentition space analysis is an essential diagnostic procedure for an accurate diagnosis and treatment planning. The trend toward earlier treatment reflects better comprehension of malocclusion and their diagnosis [9].

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. Studies by Richerdson ER, Malhotra SK [15] and Frankel HH, Benz EM [16] have found that mesiodistal tooth widths to be larger in black populations than in Caucasians.

The racial & ethnic differences in tooth sizes of various studies [16-19] 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 0.59 - 0.78 (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[3].

The correlation coefficients obtained for the Durg Chhattisgarh population, between the buccal segments of each arch were found to be smaller than for Asian American population [19] and Hong Kong Chinese [20] and greater then Pakistani [17] and Thai [18] 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 (Ingerval and Lennarston [10], De Paula *et a*l [11] and Kaplan *et al* [13]) that sex dimorphism does exist inmesiodistal 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 off our 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 [18]. From data for sexes pooled, in the present study (Table2), the coefficients of determination (r^2) show 0.445 for the maxillary teeth & 0.39 for the mandibular teeth. Therefore, 44.5 & 39 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(0.49 for the maxillary teeth & 0.44 for the mandibular teeth) than males. Among the various studies that has been done Yuen *et al* [20] in HongKong Chinese shows higher (r^2) values in male.

Using the value of coefficient, a and b listed in table 2,four equations for the prediction of upper and lower canine and premolars width in each sex were derived as follow;

Male: Maxilla:

Y = 7.77 + 0.73x Mandible:

Y = 10.95 + 0.61x

Female: Maxilla:
Y=7.43 +0.64x Mandible:
Y=9.54 +0.59x
Two studies were done similar to our study, one in Bengali population in, India, and other in Jordanian population, in Jordan in the year 2002 and 2006 respectively [20].
In Indian study, they found that both the prediction methods overestimated the actual tooth size of unerupted canine and premolars in Bengali population, therefore both prediction methods would not be as accurate in this population. Moyers chart at 65% confidence level gives more realistic estimate of width of unerupted canine and premolars as compared to 75%confidence level for Bengali population and to get more precise results in Bengali population, instead of using Tanaka Johnston prediction equations, the use of newly developed regression equations is suggested, which are As Y=9.5+.488 (X) for lower arch, Y=10.3+.493(X) for upper arch [22].
For Jordanian population they found except for the maxillary arch in male subjects,Tanaka and Johnston regression equations under estimated the mesiodistal widths of permanent canines and premolars. On the other hand, there were no statistically significant differences between actual mesiodistal widths of canines and premolars and the predicted widths from Moyers charts at the 65% and 75% level for the lower and upper arches in male subjects and at the 85%level for the upper and lower arches in female subjects [21].
In agreement with previous studies concluding that Moyer's regression equations are not an accurate method for the prediction of the size of unerupted permanent teeth in different populations [17-20].We showed in this study that Moyer's tables cannot be used at the recommended 75% probability, since significant differences were observed for the actual widths of the canine and premolars segment and those predicted by Moyer's probability tables.
The use of the 75th percentile level allows over prediction in mandibular arch of males and maxillary arch for females and offers extra protection in patients with more crowding than spacing. The experienced clinician might choose to use the 50th percentile level because it is a more precise estimate, and the error would be equally distributed on both sides. In addition to this, some authors recommend under prediction because it results in a more conservative clinical approach ,and unnecessary extractions can be avoided.[13] The proposed new probability tables for Durg Chhattisgarh population are based on the 50th percentile level and considered more accurate and relevant to this specific population for mandibular arch in males and maxillary arch for females. They can therefore be applied to determine the sum of the mesiodistal dimensions of unerupted permanent canines and premolars when the four mandibular permanent incisors are fully erupted [22].
These prediction tables, based on data from a small sample of Durg Chhattisgarh, should be accurate when applied to local children, despite the ethnic diversity in our sample. The prediction table is convenient to use and does not require memorizing equations. Further investigations with larger samples, including more ethnic groups, are required to collect more representative odontometric data for Chhattisgarh. We recommend that validating studies (based on similar samples) must be conducted to confirm the applicability and precision of the new regression equations. Additionally, the accuracy of these equations should be tested in various ethnic groups in Chhattisgarh population to further generalize their applicability.

CONCLUSION

Significant sexual dimorphism in tooth size exists among Durg Chhattisgarh population. No difference in the mesiodistal widths of canines and premolars between the left and right sides was observed. The prediction equations of Tanaka and Johnston and the charts of Moyers (75%) did not accurately predict the mesiodistal diameters of unerupted canines and premolars in Durg Chhattisgarh population. There is a linear relationship between the sum of the mandibular incisor widths and those of the canines and premolars.The regression equations proposed in this study are a good prediction method to determine widths of the maxillary and mandibular permanent canine and premolars for Durg Chhattisgarh population.

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CITATION OF THIS ARTICLE

D S Rajput, N Gupta, S Goel, T Choudhari, S Datar, J S Biswas. Evaluation and Applicability of Tanaka and Johnston and Moyers Mixed Dentition Space Analysis in a Population of Durg Chhattisgarh. Bull. Env.Pharmacol. Life Sci., Spl Issue [1] 2022 : 1393-1399