Original Article

Mixed dentition analysis – Applicability of two non-radiographic methods for Chennai school children

Naveen Kumar Kommineni, Chowdavaram Venkat Subba Reddy[1], Nelapati Sarath Chandra[1], Dappili Swami Ranga Reddy[2], Avula Kishore Kumar[1], Maram Vinay Chand Reddy

Departments of Pedodontics and Preventive Dentistry, [1]Periodontics and [2]Conservative Dentistry and Endodontic, Chadalawada Krishna Srinivasa Teja Institute of Dental Sciences, Tirupati, Andhra Pradesh, India

Corresponding author: (email: <naveenkommineni@gmail.com>)
Dr. Naveen Kumar Kommineni, Department of Pedodontics and Preventive Dentistry, Chadalawada Krishna Srinivasa Teja Institute of Dental Sciences, Tirupati - 517 507, Andhra Pradesh, India.

Abstract

Aim: To evaluate the applicability of the Tanaka and Johnston (1974) and Moyers (1988) methods in predicting the size of permanent canines and premolars in Chennai school children. **Materials and Methods:** 470 sets (127 female and 343 male) of cast models were included in the sample. Mesio-distal (m-d) widths of all teeth from left to right first molars were measured and compared with the predicted values derived from Tanaka and Johnston and Moyers methods. **Results:** There was significant bilateral symmetry and sexual dimorphism in teeth sizes seen in both the sexes. Sum of the m-d diameter of permanent mandibular incisors can be used reliably to predict the sum of m-d diameters of unerupted canines and premolars. **Conclusions:** Tanaka and Johnston's method cannot accurately predict the m-d widths. Moyers' prediction tables can be used to estimate the m-d widths of unerupted canines and premolars closer to 50% probability level.

Key words: *Mesio-distal width, mixed dentition analysis, probability tables*

INTRODUCTION

Mixed dentition is a transition period of occlusion that has both primary and permanent teeth, usually lasts from 6 to 12 years, and is associated with maximum orthodontic problems due to the inadequacy of space for erupting permanent teeth. An early assessment of available space may permit early intervention or minimize the developing malocclusion.

Mixed dentition analysis provides a reliable estimation of the size of unerupted canines and premolars, and leads to an early interruption of potential malocclusions by determining the treatment plan which would involve serial extraction, guidance of eruption, space maintenance, space regaining, or just periodic observation. The dental literature is replete with investigations focusing on the comparative accuracy, reliability, and reproducibility of various mixed dentition space analysis techniques. To date, no technique has been shown to be significantly superior over others in its predictive ability. Classically, mixed dentition analysis techniques rely on one of the following methods:[1]

- The estimation of unerupted tooth size by radiographic measurement (e.g. Nance[1]);
- Predictions based on correlations between the sizes of different types of teeth within a dentition (e.g. Tanaka and Johnson,[2] Moyers[3]); and
- A combination of both methods (e.g. Hixon and Oldfather,[4] Staley and Kerber.[5]).

Calculations from the prediction equations and tables have been widely accepted and can be used with equal reliability both by a beginner and an expert, as they do not require sophisticated clinical training and save time. They require no specific equipment or radiographic projections and may be used for both arches. Although best done on dental casts,

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they can be done with reasonable accuracy in the mouth. Accuracy of Moyers' and Tanaka Johnston's methods was fairly good.[6] Both techniques were developed using the population that was probably of northern European ancestry, and was proved by certain studies that it is difficult to apply in other populations because of the variation in tooth size.[7-9] This led us to evaluate the applicability of the Tanaka and Johnston's and Moyers' methods of predicting the size of permanent canines and premolars in Chennai school children in the present study.

MATERIALS AND METHODS

Sample selection

The sample comprised of 470 children (127 female and 343 male) obtained during the school dental health camps conducted in and around Chennai.

Ethical approval was obtained from the institutional review board and from Tamil Nadu Dr. M. G. R Medical University. Written consent was obtained from the parents of all children who underwent dental examination and impressions.

Standard orthodontic trays were used for taking impressions with alginate material in the usual manner and were poured in dental stone immediately to reduce any error.[10,11]

All children were subjected to clinical examination at the start of the study, with medical and dental histories taken. The sample criteria included:

- Indigenous Chennai patients of South Indian descent with fully erupted permanent incisors, permanent canines, and premolars in both maxillary and mandibular arches
- The patients had to be free of any systemic disease or serious health problems
- Patients with teeth free from restorations, proximal wear, fractures, or proximal caries as determined by clinical examination
- Patients with teeth free from any hypoplasia or other dental anomalies as in number, size, and shape of the teeth
- Maximum age of 15 years to preclude any discrepancies due to significant proximal wear.[10]
- High-quality dental study casts were free from any distortions.[12]

Measurement of m-d tooth widths

- A set of both maxillary and mandibular study casts from each patient was serialized and the names kept anonymous
- A Vernier gauge calibrated with digital micrometer, whose measuring beaks were sharpened, was used to measure the m-d width of the individual teeth from unsoaped study casts[13]
- All the teeth from left second premolar through to the right second premolar of each set of dental casts were measured to the nearest 0.01 mm
- M-D width was measured between two anatomical contact points of each tooth, parallel to the occlusal surface of the teeth and also parallel to the vestibular surface of the model[14]
- When a tooth was rotated or malposed in relation to the dental arch, the measurement was taken between the points on the approximate surface of the crown, where it was judged that normal contact should have occurred with the neighboring tooth[14]
- All the measurements were recorded to 0.01 mm, and entered on an Excel spreadsheet.

The sums of the following groups of teeth were pooled and the mean m-d diameter was calculated for each sex and the whole sample:

- The four mandibular incisors
- The mandibular canines and premolars per quadrant
- The maxillary canines and premolars per quadrant.

Data analysis

Statistical analysis was carried out using SPSS software (version 11.0). The two-tailed paired *t*-tests were used to assess the bilateral symmetry of m-d diameter of all individual teeth and the combined m-d diameter of canines and premolars of each arch. Independent *t*-tests were used to compare the measured values of male and female subjects. Paired *t*-test was used to check the significance of the difference between the predicted and measured m-d diameter for each method.

RESULTS

The mean values of m-d widths of the individual teeth obtained for male subjects and female subjects are tabulated in Table 1. The basic measured data obtained is used for all the regression equations and it is also helpful in providing the odontometric data of South Indian children.

There were no significant differences between measurements of contralateral teeth ($P > 0.05$) except for the maxillary and mandibular second premolars.

Table 2 shows no significant differences between measurements of contralateral teeth ($P > 0.05$) except for the maxillary lateral incisors, first molars, and mandibular first molars ($P < 0.05$).

Table 1: Measurement of individual teeth in males and females

Teeth (mean±SD)	Maxilla						Mandible					
	CI	LI	C	Pm1	Pm2	M	CI	LI	C	Pm1	Pm2	M
Males	8.75± 0.51	7.04± 0.48	7.88± 0.38	7.12± 0.38	6.66± 0.46	10.29± 0.53	5.49± 0.36	6.09± 0.46	6.93± 0.39	7.19± 0.35	7.08± 0.38	11.21± 0.55
Females	8.54± 0.44	6.79± 0.50	7.50± 0.34	6.68± 0.28	6.34± 0.28	10.10± 0.55	5.38± 0.28	5.98± 0.40	6.69± 0.36	6.87± 0.29	6.78± 0.37	10.94± 0.52

CI = Central incisor, LI = Lateral incisor, C = Canine, Pm1 = First premolar, Pm2 = Second premolar, M = First molar

Table 2: Comparison of left and right mesio-distal widths of individual teeth for the whole sample

Teeth	Maxilla						Mandible					
	CI	LI	C	Pm1	Pm2	M	CI	LI	C	Pm1	Pm2	M
Mean±SD	0.01± 0.05	0.01± 0.16	0.01± 0.08	0.02± 0.09	0.02± 0.03	0.03± 0.19	0.01± 0.02	0.01± 0.02	0.01± 0.07	0.01± 0.03	0.06± 0.09	0.01± 0.16

CI = Central incisor, LI = Lateral incisor, C = Canine, Pm1 = First premolar, Pm2 = Second premolar, M = First molar

Table 3 shows the descriptive statistics of the sum of the measured m-d values for analysis. To measure the variation in tooth m-d widths between male and female subjects, statistical analysis of the data was performed based on the average m-d tooth widths on the left and right sides of the dental arch. Since significant bilateral asymmetry had not been demonstrated in the present data, to statistically compare the male and female m-d tooth widths of each tooth, an average m-d width of both left and right sides was taken for analysis. As the number of subjects in the male group was more than the number of female subjects, independent sample *t*-tests were performed to compare the m-d tooth widths.[15,16]

Graphic representation was used since the sample size was more, and it is a simpler representation for the comparison of predicted values of unerupted maxillary canine and premolars derived from Moyers' prediction chart and Tanaka Johnston's equation at various probability levels and the measured values of subjects.

Scattergrams in the preliminary analysis of the present data showed that Moyers' predictions at 5%, 15%, 75%, and 95% confidence intervals did not compare closely with the measured values of combined m-d diameter of canines and premolars in both the mandibular and maxillary arches of males and females.

Graphs 1-4 represent the results of the Chi-square test for the differences between the sum of m-d diameter of canines and premolars in both the arches and the predicted values derived from Moyers. The measured values of the sum of m-d diameter of canines and premolars in both the arches fall between 35% and 50%.

The sample distribution has high statistical significance with the values obtained only at 50% level of Moyers' probability chart and least significance with 85% level of Moyers' probability chart. Since the measured m-d widths were less than 2% of the total sample at 5%, 15%, 75%, 85%, and 95% levels of Moyers' probability chart, they were not used in graphic representation.

Table 3: Descriptive statistics of the sum for the measured values for analysis (*N*=470)

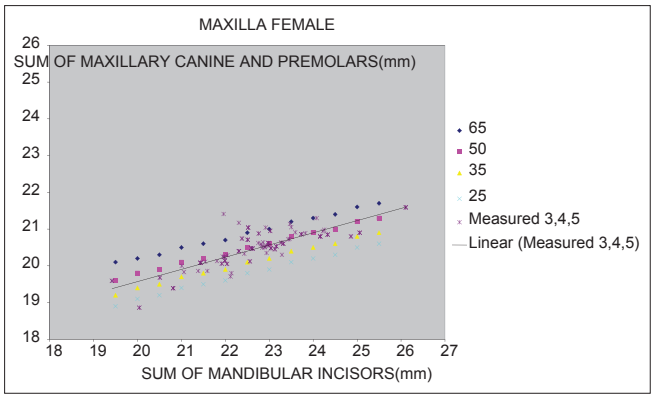
	Sex		*P* value
	Male	Female	
UR	21.66±0.95	20.52±0.56	<0.001
UL	21.65±0.91	20.48±0.50	<0.001
LR	21.20±0.87	20.34±0.74	<0.001
LL	21.28±0.89	20.44±0.79	<0.001
SLI	23.18±1.43	22.75±1.25	<0.001

UR = Sum of upper right canine and premolars, UL = Sum of left canine and premolars, LR = Sum of lower right canine and premolars, LL = Sum of lower left canine and premolars, SLI = Sum of lower incisors

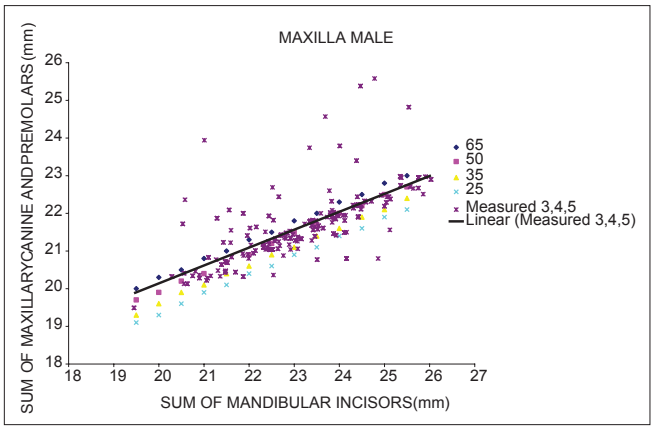
The results of correlation coefficient with two-tailed significance test of Tanaka and Johnston showed no significance, but when it was compared with Friedman two-way analysis of variance (ANOVA) test, the measured values showed a positive correlation at a sum of lower incisors plus 10 (11 according to Tanaka and Johnston) for the maxillary arch and lower incisors plus 9.5 (10.5 according to Tanaka and Johnston) for the mandibular arch, but there was overestimation seen in both arches which is represented in Graphs 5 and 6.

DISCUSSION

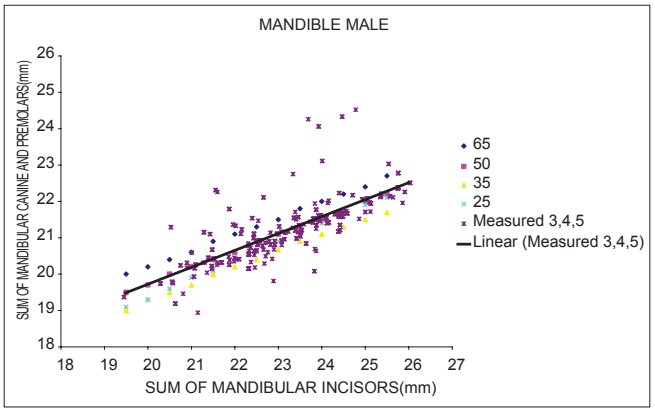
In the present study, basic measured data obtained were used for all the regression equations and they were also helpful in providing the odontometric data of South Indian children. No significant differences between measurements of contralateral teeth except for the



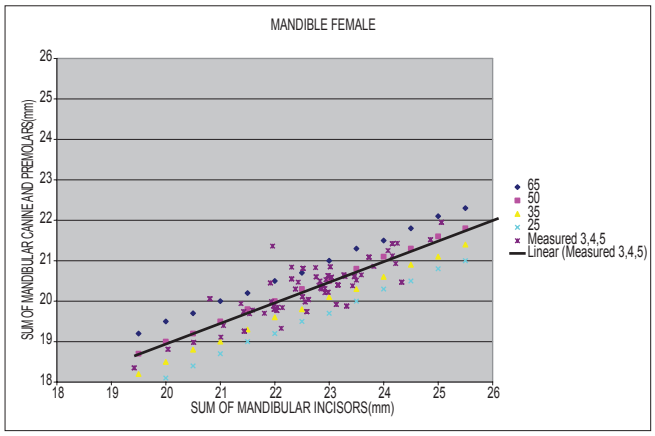
Graph 1: Graphic comparison of the predicted values of unerupted maxillary canine and premolars derived from Moyers' prediction chart at various probability levels and the measured values of female subjects



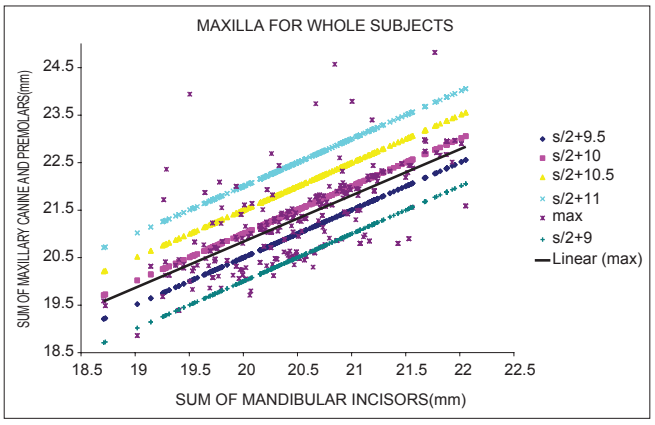
Graph 2: Graphic comparison of the predicted values of unerupted maxillary canine and premolars derived from Moyers' prediction chart at various probability levels and the measured values of male subjects



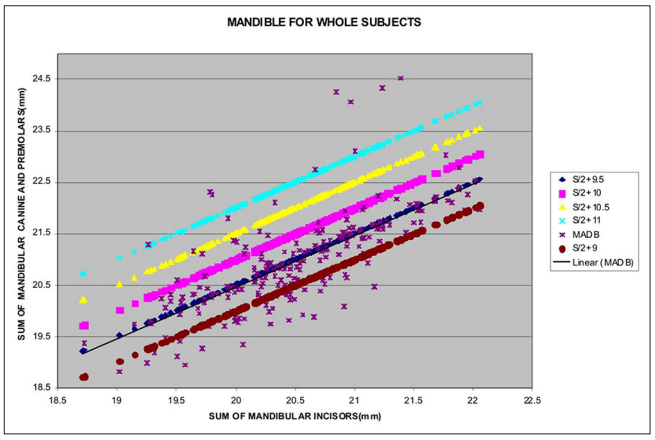
Graph 3: Graphic comparison of the predicted values of unerupted mandibular canine and premolars derived from Moyers' prediction chart at various probability levels and the measured values of male subjects



Graph 4: Graphic comparison of the predicted values of unerupted mandibular canine and premolars derived from Moyers' prediction chart at various probability levels and the measured values of female subjects



Graph 5: Graphic comparison of the predicted values of unerupted maxillary canine and premolars derived from Tanaka Johnston equation at various probability levels and the measured values of the whole sample



Graph 6: Graphic comparison of the predicted values of unerupted mandibular canine and premolars derived from Tanaka Johnston equation at various probability levels and the measured values of the whole sample

maxillary lateral incisors, first molars, and mandibular first molars. The present findings were found to agree with those of other investigators.[7,17-20]

Significant differences were found with regard to gender. The mean m-d tooth width of male subjects was consistently higher than that of females in both

maxillary and mandibular arches. It was also interesting to note that mandibular incisor showed the smallest differences between sexes. This was consistent with the results reported by Al-Bitar,[21] Jensen,[17] Bishara *et al*.,[20] Hattab *et al*.,[22] and Yeun *et al*.[23] Thus, this necessitates the need for separate prediction formula and probability tables for males and females.

Assessing the intra-examiner variability, which ranged from 0.01 to 0.19 in a sample size of 200, the error of measurement was ≤0.11 in all teeth except for maxillary central incisor, lateral incisor, first molar, and mandibular first molar where it was ≤0.19. These values can be compared favorably with those reported by other investigators.[17,24-26] Any differences in the m-d tooth width, if observed, may be a result of tooth size variability in the present sample and the prediction methods examined. To check the inter-examiner variability, a sample size of 30 was used, where the standard error of measurement was within 0.2 mm for all except maxillary first molar, for which 0.23 was obtained. This was consistent with the results of Seipel,[24] Jensen *et al*.,[17] and Keene.[26]

In all the graphic representations, it can be observed that Moyers' 50% probability level was closer to the actual measured values of the sum of m-d diameter of canines and premolars than the corresponding sum of the m-d diameter of mandibular incisors. Even the measured values of the sum of m-d diameter of canines and premolars in both the arches ranged between 35% and 50%; when the linear regression line was drawn over plotted graph, the line followed a close association with the 50% probability level.

The present study revealed that the estimated prediction of the sum of m-d diameter of canines and premolars was closer to the 50% probability of Moyers, but a slight overestimation was seen in the maxilla when the sum of the m-d widths of permanent mandibular incisors was more than 24 mm. The estimation was found to be more accurate for mandibular buccal segments at 50% probability value of Moyers. Similar findings were reported by Zilberman *et al*.,[27] for Israeli children and Al-Khadra[28] for Saudi Arabian populations, where more accuracy was obtained in predicting mandibular buccal segment when compared to the maxillary buccal segments.

The correlation coefficients calculated in the present study differ from those published by Tanaka and Johnston in that the mandibular incisors showed a minimal correlation (0.61) for the mandibular buccal segments (Tanaka and Johnston, $r = 0.65$) and more variation in correlation (0.57) was obtained for the maxillary buccal segments (Tanaka and Johnston, $r = 0.62$). Similar conclusions were made in studies by Moorrees and Reed,[7] Tanaka and Johnston,[2] Zilberman *et al*.,[27] and Diagne *et al*.[29]

In the present study, the prediction equation was applied at a sum of lower incisors plus 10 for the maxillary arch and lower incisors plus 9.5 for the mandibular arch. Even when there was a positive correlation between the sum of the m-d diameter of permanent mandibular incisors and the sum of m-d diameter of canines and premolars in the mandibular arch, when Tanaka and Johnston equations were applied, with the Friedman two-way ANOVA test, the estimated values were higher compared to the measured values. This was shown clearly in the graphical representation of Tanaka and Johnston equations at different estimated levels for the measured values for maxilla and mandible. Similar conclusions were made by Moorrees and Reed,[7] Zilberman *et al*.,[27] Al-Khadra,[28] and Nourallah *et al*.,[30] where the predicted values were higher compared to the measured values. This clearly indicates that this method showed variation in the prediction of m-d widths of canines and premolars in our population. So, the original Tanaka and Johnston equation cannot be applied for Chennai children.

CONCLUSION

- Males had larger teeth compared to females
- Variation in the dimensions between right and left was seen with maxillary lateral incisors and maxillary and mandibular first permanent molars, and the average mean value of all other teeth in both the arches showed no variation between right and left sides
- Moyers technique produces more consistent space predictions at different percentiles between males and females, which indicates separate tables have to be used for males and females, and there was an overestimation in the maxilla when the sum of the m-d widths of permanent mandibular incisors was more than 24 mm
- The original Tanaka and Johnston formula overestimated the predicted values of unerupted canines and premolars.

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