Print ISSN: 2321-6379
Online ISSN: 2321-595X

Original Article

# Comparison Of Predictability of Moyers and Tanaka Johnson Mixed Dentition Analyses in Kottayam–Kerala Population

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## Abstract

**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.

**Aims:** The aims of this study were to evaluate the applicability of the Tanaka and Johnston (1974) and Moyers (1988) mixed dentition analyses in predicting the size of permanent canines and premolars in children of Kottayam population.

**Methods:** Cast models of 100 (50 females and 50 males) children aged between 12 and 16 years of age were included in the sample. Mesiodistal (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.

**Conclusion:** Moyers prediction tables closer to 75% probability level Tanaka and Johnston's method cannot accurately predict the m-d width of unerupted canine and premolars. Both these methods underestimate the values. A new regression equation that better defines the mesiodistal width of canines and premolar is required for the children of Kottayam population and it is derived.

**Key words:** Kottayam, Moyer's analysis, Regression equation, Tanaka Johnston analysis

## INTRODUCTION

The period of mixed dentition is a critical period for the prevention or interception of any developing malocclusion. Dental crowding is one of the most frequent dental problems in the general population. It is described as the discrepancy between tooth size and arch perimeter. Early diagnosis and successful treatment of dentoalveolar discrepancies can help in achieving the goals of occlusal harmony, function, and dental facial esthetics. In the transition (mixed) dentition, it is possible to accurately determine whether combined mesial-distal tooth size will be balanced with alveolar arch size in later life. This process of determination is called mixed dentition space analysis. The method of mixed dentition analysis predicts the mesiodistal width of permanent unerupted canines and premolars. It is a diagnostic tool that allows to quantify crowding and to predict dentoalveolar discrepancy by identifying the available and necessary space for teeth not yet erupted.

There have been various methods developed for space analysis and prediction of the sizes of unerupted teeth. The three basic approaches of predicting mesiodistal

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www.ijss-sn.com

Month of Submission : 02-2023
Month of Peer Review : 03-2023
Month of Acceptance : 04-2023
Month of Publishing : 04-2023

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width of the permanent canines and premolars are direct measurements from the radiographs, correlation-statistical methods, and combination of radiographs and correlation-statistical methods. The prediction methods of Moyers and the Tanaka-Johnston mixed dentition space analysis have been widely adopted and are most commonly used in clinical practices. Moyers mixed dentition analysis is a non-radiographic method which uses mesiodistal width of four permanent lower incisors and a prediction table for unerupted canines and premolars, with percentiles ranging from 50 to 95 for American children.[1] Percentile 75 is recommended when applying the analysis in different populations. On the other hand, the Tanaka-Johnston analysis also uses mesiodistal width of four permanent lower incisors to develop regression equations for predicting the sizes of the unerupted canines and premolars.[2]

Moyers analysis was developed from data obtained from North American children, whereas Tanaka and Johnston equations were assembled on the basis of a sample of individuals of European descent. Evidence of racial tooth size variability, however, suggests that the prediction techniques based on a single racial sample may not be considered universal. Hence, it is important to evaluate the applicability of the Moyers and Tanaka-Johnston methods of mixed dentition analysis for various populations. Hence, the present study was carried out to determine the applicability of Moyers and Tanaka-Johnston mixed dentition analysis methods of prediction of width of unerupted permanent canines and premolars in Kottayam, Kerala population.

## MATERIALS AND METHODS

The study sample consisting of 100 children (50 males and 50 females) within the age group of 12–16 years having full complement of erupted canine and premolars in both the arches from various areas of Kottayam district presenting to the outpatient department of Government Dental College, Kottayam. Details of procedure were thoroughly explained to parents and informed consent was obtained before study. Alginate impressions of both the maxillary and mandibular arches were made. The impressions were poured immediately in dental stone to prevent dimensional changes. The measurements of teeth on dental casts were done using a calibrated digital caliper with an accuracy of 0.01 mm. The greatest mesiodistal dimensions of the right and left canine and premolars of both maxillary and mandibular arches were measured separately and recorded (measured values). Sum of the mesiodistal width of four mandibular incisors were recorded to obtain the space for the eruption of canine and premolars for both the arches using Moyer's and Tanaka Johnston analysis (predicted value). All measurements were carried out twice and the mean of the two values were considered. Measured values were compared with the predicted values obtained by Moyers and Tanaka-Johnston mixed dentition analysis methods.

### Inclusion Criteria

The following criteria were included in the study:

- The subjects were of Kottayam district for at least 1 year
- The subjects were in the age group of 12–16 years
- The teeth were free of proximal restorations, fractures, proximal caries, hypoplasia, or any anomalies of the teeth
- No developmentally missing or supernumerary teeth were present
- Subjects with severe crowding and who had previous orthodontic treatment were excluded.

### Moyers Method[1](1988)

Predicted values of Moyers mixed dentition analysis are obtained using the sum of mesiodistal width of four permanent lower incisors and a prediction table for non-erupted canines and premolars, with percentiles ranging from 50 to 95 for American children. Percentile 75 is recommended when applying the analysis in different populations. The predicted values were compared with the measured values.

### Tanaka-Johnston Method[2] (1974)

According to these equations, the sum of the mesiodistal width of four mandibular incisors is used to predict the mesiodistal width of unerupted permanent canines and premolars as follows:

For maxillary arch:

$Y = 11.0 + 0.5 (X)$

For mandibular arch:

$Y = 10.5 + 0.5 (X)$

Where,

Y = the predicted value of the sum of the mesiodistal width of the unerupted canines and premolars on either the right or left side.

X = the sum of the mesiodistal width of the four mandibular incisors.

The difference between the measured values of sum of mesiodistal width of the canine and premolars and the predicted values according to Moyers and Tanaka-Johnston methods were tested for significance using students unpaired *t*-test and compared using Pearson correlation.

## RESULTS

Comparison of combined mesiodistal width of canine and premolars in maxillary and mandibular right and

left quadrants with the measured value of maxillary and mandibular right and left quadrants, respectively, was found to be statistically insignificant with $P = 0.754$ (>0.05) and 0.657 (>0.05) [Table 1].

Correlation of Moyers analysis in Maxillary right and left quadrants shows difference in values of mesiodistal width of canine and premolars obtained by direct measuring and that obtained from Moyers analysis in maxillary right and left quadrants, respectively, which were found to be statistically significant ($P < 0.05$) [Table 2].

Correlation of Moyers analysis in mandibular right and left quadrants shows difference in values of mesiodistal width of canine and premolars obtained by direct measuring and that obtained from Moyers analysis in mandibular right and left quadrants, respectively, which were found to be statistically significant ($P < 0.05$) [Table 3].

Correlation of Tanaka Johnson analysis in maxillary right and left quadrant shows difference in values of mesiodistal width of canine and premolars obtained by direct measuring and that obtained from Tanaka Johnson analysis in maxillary right and left quadrant, respectively, which is statistically significant ($P < 0.05$) and having a correlation only 0.813 [Table 4].

Correlation of Tanaka Johnson analysis in mandibular right and left quadrant shows difference in values of mesiodistal width of canine and premolars obtained by direct measuring and that obtained from Tanaka Johnson analysis in mandibular right and left quadrant which is statistically significant with $P < 0.05$ [Table 5].

### Regressive Equations for Males and Females

Both Moyer's and Tanaka Johnston mixed dentition analysis are having a low correlation value among the population under our study. Hence, a new regression equation with a high correlation value was derived. Linear regression is used to predict the width of unerupted canines and premolars using the width of anterior teeth in Kottayam population.

Regressive equations for maxilla of males [Table 6 and Figure 1].

Regressive equations for mandible of males [Table 7 and Figure 2].

Regressive equations for maxilla of females [Table 8 and Figure 3].

Regressive equations for mandible of females [Table 9 and Figure 4].

**Table 1: Comparison of combined mesiodistal width of canines and premolars on the right and left quadrants of maxillary and mandibular arch**

| Quadrant | Side | *n* | Mean±SD | *P* |
|---|---|---|---|---|
| Maxillary | Right | 100 | 22.75±1.28 | 0.754 |
| | Left | 100 | 22.69±1.24 | |
| Mandibular | Right | 100 | 21.55±1.52 | 0.657 |
| | Left | 100 | 21.64±1.47 | |

SD: Standard deviation

**Table 2: Correlation of Moyers analysis in maxillary right and left quadrants with the measured value**

| Quadrant and side | *n* | *P* | Pearson correlation |
|---|---|---|---|
| Maxillary right | | | |
| Measured value | 100 | 0.000 | 0.706 |
| Moyers analysis | 100 | | |
| Maxillary left | | | |
| Measured value | 100 | 0.000 | 0.723 |
| Moyers analysis | 100 | | |

**Table 3: Correlation of Moyers analysis in mandibular right and left quadrants with the measured value**

| Quadrant and side | *n* | *P* | Pearson correlation |
|---|---|---|---|
| Mandibular right | | | |
| Measured value | 100 | 0.000 | 0.576 |
| Moyers analysis | 100 | | |
| Mandibular left | | | |
| Measured value | 100 | 0.000 | 0.710 |
| Moyers analysis | 100 | | |

**Table 4: Correlation of Tanaka Johnson analysis in maxillary right and left quadrants with the measured value**

| Quadrant and side | *n* | *P* | Pearson correlation |
|---|---|---|---|
| Maxillary right | | | |
| Measured value | 100 | 0.000 | 0.813 |
| Tanaka Johnson analysis | 100 | | |
| Maxillary left | | | |
| Measured value | 100 | 0.000 | 0.813 |
| Tanaka Johnson analysis | 100 | | |

**Table 5: Correlation of Tanaka Johnson analysis in mandibular right and left quadrants with the measured value**

| Quadrant and side | *n* | *P* | Pearson correlation |
|---|---|---|---|
| Mandibular right | | | |
| Measured value | 100 | 0.000 | 0.580 |
| Tanaka Johnson analysis | 100 | | |
| Mandibular left | | | |
| Measured value | 100 | 0.000 | 0.722 |
| Tanaka Johnson analysis | 100 | | |

## DISCUSSION

Moyers mixed dentition analysis uses sum of mesiodistal width of four permanent lower incisors and a prediction table for non-erupted canines and premolars, with percentiles ranging from 50 to 95 for American children. Percentile 75 is recommended when applying the analysis in different populations. On the other hand, the Tanaka-Johnston mixed dentition analysis uses the sum of mesiodistal width of the mandibular central and lateral incisors to develop regression equations for predicting the sizes of the unerupted canines and premolars.

Moyers analysis was developed from data obtained from North American children, whereas Tanaka and Johnston equations were assembled on the basis of a sample of individuals of European descent. Evidence of racial tooth size variability however suggests that the prediction techniques based on a single racial sample may not be considered universal. Schirmer and Wiltshire,[3] Nourallah *et al.*,[4] and Bonetti *et al.*[5] evaluated the applicability of Tanaka and Johnston's and Moyers' methods for black South Africans, Syrians, and northern Italians, respectively. These studies confirmed statistically significant differences between the predicted and actual mesiodistal width of permanent canines and premolars using Moyers and Tanaka-Johnston mixed dentition analyses when applied to different racial groups. Hence, the present study was carried out to determine the applicability of above-mentioned mixed dentition methods of prediction of width of unerupted permanent canines and premolars in Kottayam district in Kerala population.

When the Tanaka-Johnston mixed dentition analysis method was applied on the Kottayam children sample, it was found that the Tanaka-Johnston equations also show deviation from actual measured value Tanaka Johnson equations also underestimated the estimated the actual values of sum of the mesiodistal width of the canine and premolars in both dental arches in total sample as well as in both sexes separately. There were statistically significant differences between the predicted values and their actual values. Similar results are also seen with studies conducted by Schirmer and Wiltshire[3] in 1997 and Jaroontham and Godfrey[6] These results are contrary to several studies conducted by Ramesh *et al.*[7] in Kodava population, Buwembo *et al.*[8] for Ugandan population and Grover *et al.* (2017)[9] for Lucknow population. They found that the Tanaka-Johnston prediction equations overestimated the actual values of the sum of canine and premolars. Underprediction has also been found with Tanaka-Johnston equations in other populations including Asian Americans by Lee-Chan *et al.*[10] and Hong Kong Chinese by Yuen *et al.*[11] Kaplan *et al.*[12] found that both Moyers and

**Table 6: Regressive equations for maxilla of males**

| Model 1 | Coefficients | | | | |
|---|---|---|---|---|---|
| | Unstandardized coefficients | | Standardized coefficients β | *t* | Significant |
| | B | SE | | | |
| Constant | 7.302 | 1.814 | | 4.025 | 0.000 |
| SOIs | 0.666 | 0.076 | 0.784 | 8.745 | 0.000 |

SOIs: Sum of incisors, SE: Standard error

**Table 7: Regressive equations for mandible of males**

| Model 1 | Coefficients | | | | |
|---|---|---|---|---|---|
| | Unstandardized coefficients | | Standardized coefficients β | *t* | Significant |
| | B | SE | | | |
| Constant | 6.014 | 2.456 | | 2.449 | 0.018 |
| SOIs | 0.679 | 0.103 | 0.689 | 6.589 | 0.000 |

SOIs: Sum of incisors, SE: Standard error

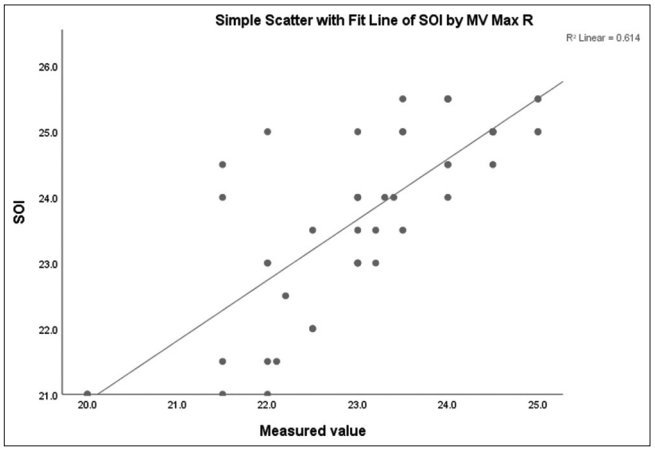


**Figure 1: Sum of m-d width of canine plus premolar = 7.302+0.666 SOI**

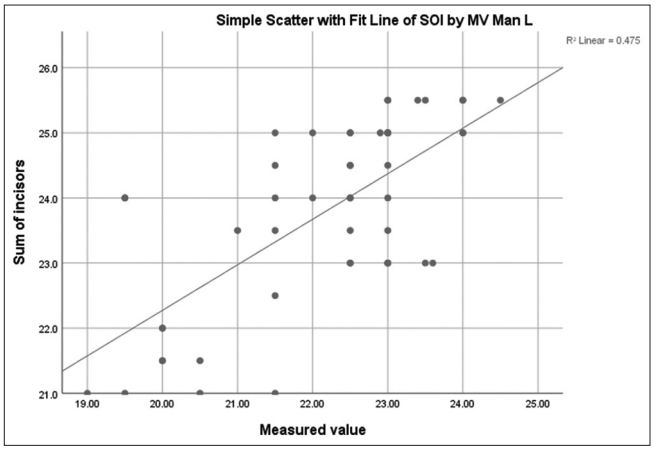


**Figure 2: Sum of m-d width of canine plus premolar = 6.014+0.679 SOI**

Tanaka-Johnston equations tend to overestimate the size of unerupted canines and premolar.

**Table 8: Regressive equations for maxilla of females**

| Coefficients | | | | | |
|---|---|---|---|---|---|
| Model 1 | Unstandardized coefficients | | Standardized coefficients β | *t* | Significant |
| | B | SE | | | |
| Constant | 6.612 | 1.679 | | 3.937 | 0.000 |
| SOIs | 0.704 | 0.075 | 0.805 | 9.403 | 0.000 |

SOIs: Sum of incisors, SE: Standard error

**Table 9: Regressive equations for mandible of females**

| Coefficients | | | | | |
|---|---|---|---|---|---|
| Model 1 | Unstandardized coefficients | | Standardized coefficients β | *t* | Significant |
| | B | SE | | | |
| Constant | 6.854 | 2.305 | | 2.974 | 0.005 |
| SOIs | 0.637 | 0.103 | 0.667 | 6.205 | 0.000 |

SOIs: Sum of incisors, SE: Standard error

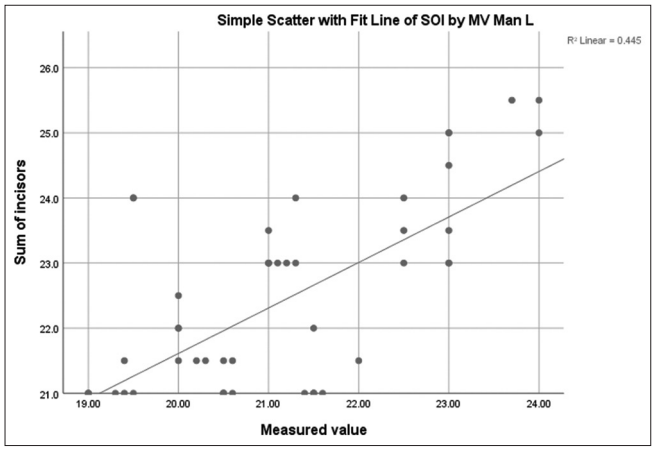


**Figure 3: Sum of m-d width of canine plus premolar = 6.612+0.704 SOI**

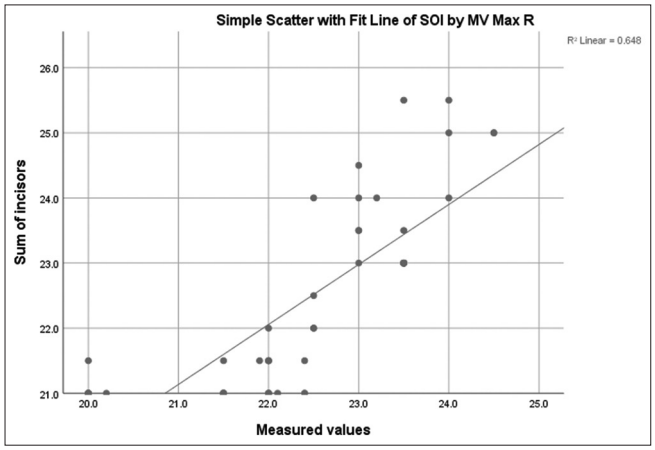


**Figure 4: Sum of m-d width of canine plus premolar = 6.854+0.637SOI**

Racial and gender specific-mixed dentition analyses require revision and validation once every generation due to changing trends in malocclusion and tooth size. Hence, we have derived four different equations for Kottayam population, two for males and two for females based on the sum of mandibular incisors as independent variable. The equations are given down as follows.

### Equation for Male

- Maxillary quadrant: 7.302+0.666×
- Mandibular quadrant: 6.014+0.679×

### Equation for Female

- Maxillary quadrant: 6.612+0.704×
- Mandibular quadrant: 6.854+0.637×

## CONCLUSION

Moyers at 75% and Tanaka-Johnston mixed dentition analysis methods were not applicable for children of Kottayam population as both these methods underestimated the sum of the mesiodistal width of the permanent canine and premolars in both dental arches. Hence, we have derived four different equations for Kottayam population, two for males and two for females. New more accurate prediction equations which add sum of the mesiodistal width of the permanent canine and premolars in both arches for total sample as well as separately for male and female children have been formulated.

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**How to cite this article:** Joseph J, Kumar TVA, Rehna S, Vaishak Nath P, Anagha S. Comparison of Predictability of Moyers and Tanaka Johnson Mixed Dentition Analyses in Kottayam–Kerala Population. Int J Sci Stud 2023;11(1):69-74.

**Source of Support:** Nil, **Conflicts of Interest:** None declared.