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Original Article

# Evaluation of Three Different Regression Equations Based Mixed Dentition Analysis in Children of Moradabad City, India

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## Abstract

**Objective:** To assess the accuracy and applicability of three regression equations based mixed dentition analysis in children of Moradabad city, India. **Material and Methods:** Actual mesiodistal width of maxillary and madibular incisors, canines and premolars of 100 children (50 male and 50 female) aged 11-14 years were measured on dental cast with electronic digital vernier caliper. The analysis of Tanaka- Johnston, Ling-Wong and Jaroontham-Godfrey regression equations were tested on the dental casts. All analyses were performed on SPSS software. Data were summarized as Mean ± standard deviation (SD) paired observations were compared by paired t-test (two-tailed test) while independent groups were compared by independent Student's t-test. The level of significance was at $P < 0.001$. **Results:** The analysis of Tanaka-Johnston, Ling-Wong, Jaroontham-Godfrey regression equations tended to overestimate the mesiodistal width of the canines and premolars with the actual measured values. **Conclusion:** All the three regression equations based mixed dentition overestimated the mesiodistal width of canines and premolars in Moradabad population.

**Keywords:** Dentition, Mixed; Child; Regression Analysis.

**Introduction**

Orthodontic intervention in the mixed dentition is mostly relay on a correct space analysis [1]. Mixed dentition analysis is most important criteria in determining whether a treatment plan should involve space maintenance, space regaining, serial extraction, guidance of eruption, or periodic observation [2,3].

Three main space analysis approaches have been used to estimate the mesiodistal widths of unerupted permanent canines and premolars in mixed dentition periods: (1) Measurement of mesiodistal width of unerupted teeth using radiographs; (2) Various regression equations that relate the mesiodistal widths of fully erupted teeth to those of unerupted canines and premolars; and (3) Combination of measurements from fully erupted teeth and radiographs of unerupted teeth [4-6].

The first attempts to estimate the mesiodistal width of unerupted canines and premolars were made by Black in 1897, who proposed probability tables based on average mesiodistal widths [7]. Later, Radiographs were used to determine mesiodistal width of unerupted permanent canines and premolars. Because of these methods tended to overestimate tooth widths, a mathematical proportion was proposed to compensate for image enlargement. Now a days, the methods of space analysis in mixed dentition period based on 45° cephalometric radiographs seem to be the most precise and accurate, but are time-consuming, and require sophisticated equipment [8,9]. It was reported the existence of a significant linear association between the sum of mesiodistal width of four lower permanent incisors and the sum of mesiodistal width of unerupted mandibular permanent canines and premolars (SPCP). Since then, several simple linear regression equations have been proposed for populations of different ethnic origins [10].

Regression equations mixed dentition analysis based on already erupted permanent teeth are used most widely, especially Tanaka-Johnston regression equation. Tanaka and Johnston's regression equation has several advantages such as used for both the arches and both the sexes, no need of any radiographs and can be done by beginner or expert [11].

Ling-Wong [12] and Jaroontham-Godfrey [13] regression equations are simple linear regression equation, have been proposed for Southern Chinese, Thai children population respectively and have a significant linear association between four lower permanent incisors and the unerupted permanent canines and premolars.

So, these three regression equations were developed using the samples of three different populations, and was proved by previous reported studies that it is difficult to apply in other populations because of the variation in tooth size and racial diversity. This led us to evaluate the accuracy and applicability of the three regression equations based mixed dentition analysis in predicting the size of permanent canines and premolars in Moradabad school children.

**Material and Methods**

Ethical Aspects

The present study was conducted in Department of Pedodontics and Preventive Dentistry after approval of Institutional Ethical & Review Board (IERB) of Kothiwal Dental College & Research Centre, Moradabad.

Sample and Data Collection

The subjects for the study derived from various senior secondary schools in Moradabad city, Uttar Pradesh, India after obtaining the informed consent letter from the parents. The sample of the cross sectional study included 100 children (50 male, 50 female) in the age group of 11-14 years.

Inclusion Criteria: 1) Presence of fully erupted permanent incisors, canines and premolars in the maxillary and mandibular arches; 2) No systemic diseases and craniofacial anomalies; 3) No previous history of orthodontic treatment; 4) No proximal caries, restoration, or age-related attrition; and 5) Resident of Moradabad city, Uttar Pradesh, India.

Exclusion Criteria: 1) Teeth with proximal caries, proximal wear, proximal restoration or fracture; 2) Teeth with dental anomalies which may alter the size, shape, number or form of the teeth; 3) Partially erupted teeth; and 4) Retained deciduous teeth in the dental arches.

Standard perforated orthodontic trays were used for taking impressions of the selected children. Full depth impressions of maxillary and mandibular dental arches were recorded with alginate impression material (Vignette Chromatic Dentsply, India) in the usual manner and were poured in dental stone (Kalabhai Karson Pvt. Ltd Mumbai, India) immediately to reduce any error.

Actual mesiodistal width of maxillary and mandibular incisors, canines and premolars were measured on the cast using an electronic digital caliper (Digenetic calipers, Mitutoyo Corporation, Tokyo, Japan). Mesiodistal width of each teeth was measured between two anatomical contact points with the tip of sliding caliper placed parallel to the occlusal and vestibular surfaces of the teeth [14].

To ensure reliability of measurement of mesiodistal width, two investigators blinded to the subjects and to each other measured the plaster casts. Only 10 dental study casts were measured per day selected randomly. A high Intraclass Correlation Coefficient (ICC = 0.967) ensured measurement reliability.

The regression equations used in the study:

**1) Tanaka & Johnston Method:** Marvin M. Tanaka and Lysle E. Johnston calculated Simple linear regression equations for the prediction of the mesiodistal widths of canines and premolars for a sample of 506 North European orthodontic patients. Since then, their regression equations for prediction of mesiodistal width of canines and premolars have been widely used.

$$Y = a + bx$$

For Maxillary teeth, $a = 11.0$, $b = 0.5$

For Mandibular teeth, $a = 10.5$, $b = 0.5$

$x$ = sum of four lower incisors

**2) Ling and Wong Method:** John Y. K. Ling and Ricky W. K. Wong calculated simple linear regression equation for the prediction of mesiodistal width of canines and premolars for a sample of 459 southern Chinese 12 years' old children. This regression equation is based on Tanaka and Johnston method of mixed dentition analysis.

For Maxillary unerupted Canines and Premolars:

$Y = 11.5 + 0.5X$ (Male)

$Y = 11.0 + 0.5X$ (Female)

For Mandibular unerupted Canines and Premolars:

$Y = 10.5+ 0.5X$ (Male)

$Y = 10.0 + 0.5X$ (Female)

x= sum of four lower incisors

**3) Jaroontham and Godfrey Method:** Jintana Jaroontham and Keith Godfrey calculated simple linear regression equation for the prediction of mesiodistal width of canines and premolars for a sample of 430 Northeastern Thailand Population under the age of 15 years. This regression equation is based on $75^{th}$ percentiles of original Moyer's table.

For Maxillary unerupted Canines and Premolars:

$Y = 13.36 + 0.41X$ (Male)

$Y = 11.16 + 0.49X$ (Female)

For Mandibular unerupted Canines and Premolars:

$Y = 11.92+ 0.43X$ (Male)

$Y = 9.49 + 0.53X$ (Female)

x= sum of four lower incisors

Statistical Analysis

All analyses were performed on SPSS (SPSS Inc. Version 16.0 Chicago: SPSS Inc.) software. Data were summarized as Mean ± standard deviation (SD) paired observations were compared by paired *t*-test (two-tailed test) while independent groups were compared by independent Student's *t*-test. The level of significance was at $P < 0.001$.

**Results**

In both the male and female samples the analysis of Tanaka-Johnston, Ling-Wong and Jaroontham-Godfrey regression equations demonstrated significant overestimation of the mesiodistal width of the unerupted canines and premolars. Male teeth were found to be generally larger in size compared to the females (Tables 1 and 2).

**Table 1. Distribution of mean values (actual and predicted) of maxillary canines and premolars in males and females.**

| Methods | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | N | SD | SEM | Mean | N | SD | SEM |
| Tanaka and Johnston | 21.26 | 50 | 0.574 | 0.081 | 21.15 | 50 | 0.537 | 0.076 |
| Ling and Wong | 21.75 | 50 | 0.593 | 0.083 | 21.15 | 50 | 0.537 | 0.076 |
| Jaroontham and Godfrey | 22.13 | 50 | 0.745 | 0.106 | 21.98 | 50 | 0.634 | 0.122 |
| Actual value | 19.54 | 50 | 1.161 | 0.164 | 19.22 | 50 | 1.077 | 0.152 |

SD = Standard Deviation; SEM = Standard Error of the Mean.

**Table 2. Distribution of mean values (actual and predicted) of mandibular canines and premolars in males and females .**

| Methods | Male | | | | Female | | | |
|---|---|---|---|---|---|---|---|---|
| | Mean | N | SD | SEM | Mean | N | SD | SEM |
| Tanaka and Johnston | 20.77 | 50 | 0.569 | 0.080 | 20.64 | 50 | 0.536 | 0.076 |
| Ling and Wong | 20.77 | 50 | 0.569 | 0.080 | 19.95 | 50 | 0.575 | 0.081 |
| Jaroontham and Godfrey | 21.23 | 50 | 0.745 | 0.097 | 19.14 | 50 | 1.093 | 0.155 |
| Actual value | 19.20 | 50 | 1.112 | 0.157 | 18.88 | 50 | 1.090 | 0.154 |

SD = Standard Deviation; SEM = Standard Error of the Mean.

The distribution of mean differences of mesiodistal width of maxillary canines and premolar for both the sexes as measured by Tanaka-Johnston, Ling-Wong and Jaroontham-Godfrey regression equations showed significance when compared with actual mean value (Table 3). Statistically significant differences ($P < 0.001$) were found between the actual values and the Predicted values obtained by the three used regression equations (Tables 3 and 4).

**Table 3. Comparison of means of mesiodistal width of maxillary canines and premolars in males and females.**

| Methods | Males<br>Paired Differences | | | Females<br>Paired Differences | | |
|---|---|---|---|---|---|---|
| | Mean | SD | P value | Mean | SD | P value |
| Tanaka and Johnston - Actual value | 1.73 | 0.945 | 0.000* | 1.92 | 0.894 | 0.000* |
| Ling and Wong - Actual value | 2.21 | 0.989 | 0.000* | 1.92 | 0.894 | 0.000* |
| Jaroontham and Godfrey - Actual Value | 2.59 | 1.104 | 0.000* | 2.76 | 1.002 | 0.000* |

t Test; SD = Standard Deviation; *P < 0.001: Statistically Significant.

The distribution of mean differences of mesiodistal width of mandibular canines and premolar for both the sexes as measured by Tanaka-Johnston, Ling-Wong and Jaroontham-Godfrey regression equations showed significance when compared with actual mean value. Whereas, in female samples the analysis of Jaroontham-Godfrey regression equation showed close approximation with the actual measured values (Table 4).

**Table 4. Comparison of means mesiodistal width of mandibular canines and premolars in males and females.**

| Methods | Males<br>Paired Differences | | | Females<br>Paired Differences | | |
|---|---|---|---|---|---|---|
| | Mean | SD | P value | Mean | SD | P value |
| Tanaka and Johnston - Actual Value | 1.57 | 0.837 | 0.000* | 1.76 | 0.900 | 0.000* |
| Ling and Wong - Actual Value | 1.57 | 0.837 | 0.000* | 1.07 | 0.632 | 0.000* |
| Jaroontham and Godfrey - Actual Value | 2.03 | 1.045 | 0.000* | 0.26 | .201 | 0.000* |

t Test; SD = Standard Deviation; *P < 0.001: Statistically Significant.

**Discussion**

Mixed dentition analysis is an essential part of early orthodontic diagnostic procedures required to determine the amount of mesiodistal space available for the alignment of unerupted permanent canines and premolars in a dental arches [15,16]. Most of the cases of malocclusion start during the mixed dentition period. Early orthodontic treatment reflects better comprehension of dental malocclusions [17,18]. Sum of mesiodistal width of permanent mandibular incisors are most reliable tooth combination for predicting the mesiodistal width of permanent unerupted canines and premolars in both the arches [19]. In the present study, the female samples showed a higher coefficient of correlation (r=.712) and determination (r2=.619) between sum of unerupted canines and premolars and permanent mandibular incisors as compared to male samples{coefficient of correlation (r=.671) and determination (r2=.597)}.

The age group 11-14 years was selected as at this age permanent teeth from right permanent first molar to left permanent first molar in both the arches have erupted into the oral cavity and to minimize the alteration of the mesiodistal tooth dimension because of attrition, restoration, or caries [20].

In the present study, electronic digital vernier caliper (read to the nearest 0.01mm) was used for measurements of mesiodistal width of permanent maxillary and mandibular incisors, canines and premolars on the study casts.

Tanaka and Johnston regression equation is one of the most common space analysis for predicting the mesiodistal size of unerupted canines and premolars teeth which is derived from North American children, So it's applicability on different population may be questionable due to variation in mesiodistal dimensions in different ethnic groups [21]. In the present study, when Tanaka-Johnston regression equation was applied in male and female samples, there was statistical significant difference ($p<0.001$) and clinical relevant difference (more than 1 mm) was found between the predicted and actual value of permanent maxillary and mandibular canines and premolars teeth. These finding are in accordance with some previous reported studies done on different populations samples as Iranian children [22], Brazilians children [23,24], Nepalese children [25], Turkish children [26] and Indian children [27-29].

Ling and Wong [12] developed a simple linear regression equation using sum of permanent mandibular incisors which is derived from mesiodistal measurement of Southern Chinese children. A previous study developed for Malay population found that Ling and Wong method showed statistically significant difference for males, however, there was no significant difference for females. For female Malay, the method proposed by Ling and Wong for southern Chinese females proved to be highly accurate [30]. But in our study, Ling and Wong methods showed significant difference between the actual and predicted widths of canines and premolars for both sexes in both the arches.

Jaroontham-Godfrey [13] developed a simple linear regression equation using the correlation of sum of permanent mandibular incisors and permanent maxillary and mandibular canines and premolars, which was derived from mesiodistal teeth dimension of 430 northeastern

Thailand children. Jaroontham-Godfrey reported low coefficient of determination (r2=.42) in male samples as compared to female samples. This finding was similar to present study.

Some authors reported that Jaroontham-Godfrey regression equation showed statistically significant difference for females, however, there was no significant difference for males in Malay population. For male Malay population, the method proposed by Jaroontham-Godfrey for Thai male proved to be highly accurate [30]. But in our study, Jaroontham-Godfrey regression equation showed significant difference between the actual and predicted widths of canines and premolars for both sexes in both the arches and some close approximation with the actual measured values for mandibular canines and premolars in female samples.

**Conclusion**

Tanaka Johnston, Ling-Wong, Jaroontham-Godfrey regression equations significantly overestimate the mesiodistal widths of the permanent canines and premolars of children's of Moradabad city, Uttar Pradesh, India. Further studies are required based on larger sample size, to confirm the applicability.

**References**

1. Lima Martinelli F, Martinelli de Lima E, Rocha R, Souza Tirre-Araujo M. Prediction of lower permanent canine and premolars width by correlation methods. Angle Orthod 2005; 75(5):805-8.

2. Memon S, Fida M. Comparison of three mixed dentition analysis methods in orthodontic patients at AKUH. J Coll Physicians Surg Pak 2010; 20(8):533-7. doi: 04.2010/JCPSP.533537.

3. Bernabe´ E, Villanueva KM, Flores-Mir C. Tooth width ratios in crowded and noncrowded dentitions. Angle Orthod 2004; 74(6):765-8.

4. Gianelly AA. Treatment of crowding in the mixed dentition. Am J Orthod Dentofacial Orthop 2002; 121(6):569-71.

5. Moyers RE. Handbook of orthodontics. 3.th ed. Chicago: Year Book Medical Publishers; 1973.

6. Proffit WR, Fields HW, Sarver DM. Contemporary orthodontics. 5.th ed. St. Louis: Elsevier Mosby; 2013.

7. Black GV. Descriptive anatomy of the human teeth. 4.th ed. Ch.16. Philadelphia: SS White Dental Mfg. Co; 1897. p. 16.

8. Shah S, Bhaskar V, Venkataraghvan K, Choudhary P, Mahadevan G, Trivedi K. Applicability of regression equation using widths of mandibular permanent first molars and incisors as a predictor of widths of mandibular canines and premolars in contemporary Indian population. J Indian Soc Pedod Prev Dent 2013; 31(3):135-40. doi: 10.4103/0970-4388.117962.

9. Ibrahim I, Elkateb MA, Wahba NA, El Harouny N. A digital method to predict the mesiodistal widths of canines and premolars in an Egyptian sample. J Clin Pediatr Dent 2011; 35(4):421-8.

10. Carey CW. Linear arch dimension and tooth size. Am J Orthod 1946; 35:762-75.

11. Dasgupta B, Zahir S. Comparison of two non-radiographic techniques of mixed dentition space analysis and evaluation of their reliability for Bengali population. Contemp Clin Dent 2012; 3(Suppl 2): S146–S150. doi: 10.5402/2012/523703.

12. Ling JYK, Wong RWK. Tanaka-Johnston mixed dentition analysis for southern Chinese in Hong Kong. Angle Orthod 2006; 76(4):632-6.

13. Jaroontham J, Godfrey K. Mixed dentition space analysis in a Thai population. Eur J Orthod 2000; 22(2):127-34.

14. Moorrees CFA, Reed RB. Correlations among crown diameters of human teeth. Arch Oral Biol 1964; 9:685-97.

15. Al-Bitar ZB, Al-Omari IK, Sonbol HN, Al-Ahmad HT, Hamdan AM. Mixed dentition analysis in a Jordanian population. Angle Orthod 2008; 78(4):670-75. doi: 10.2319/0003-3219(2008)078[0670:MDAIAJ]2.0.CO;2.
16. Bernabe E, Flores-mir C. Appraising number and clinical significance of regression equations to predict unerupted canine and premolars. Am J Orthod Dentofacial Orthop 2004; 126(2):228-30. doi: 10.1016/j.ajodo.2004.03.021.
17. Sonahita A, Dharma RM, Dinesh MR, Amarnath BC, Prashanth CS, Akshai S. Applicability of two methods of mixed dentition analysis in a contemporary Indian population sample. Eur J Paediatr Dent 2012; 13(1):29-34.
18. Tikku T, Khanna R, Sachan K, Agarwal A, Srivastava K, Yadav P. A new proposed regression equation for mixed dentition analysis using the sum of permanent mandibular four incisors and first molar as a predictor of width of unerupted canine and premolars in a sample of North Indian population. J Orthod Sci 2013; 2(4):124-29. doi: 10.4103/2278-0203.123199.
19. Bernabe E, Flores-Mir C. Are the lower incisors the best predictors for the unerupted canine and premolars sums? An analysis of a Peruvian sample. Angle Orthod 2005; 75(2):202-7.
20. Boitor CG, Stoica F, Nasser H. Prediction of the mesiodistal size of unerupted canines and premolars for a group of Romanian children: a comparative study. J Appl Oral Sci 2013; 21(3):225-30. doi: 10.1590/1679-775720130030.
21. Sanches JO, Santos-Pinto LAMD, Santos-Pinto AD, Grehs B, Jeremias F. Comparison of space analysis performed on plaster vs. digital dental casts applying Tanaka and Johnston's equation. Dental Press J Orthod 2013; 18(1):128-33.
22. Tahere H, Majid S, Fateme M, Fard K, Javed M. Predicting the size of unerupted canines and premolars of the maxillary and mandibular quadrants in an Iranian population. J Clin Pediatr Dent 2007; 32(1):43-8.
23. Brito FC, Nacif VC, Melgaco CA. Mandibular permanent first molars and incisors as predictors of mandibular permanent canine and premolar widths: Applicability and consistency of the method. Am J Orthod Dentofacial Orthop 2014; 145(3):393-8. doi: 10.1016/j.ajodo.2013.01.024.
24. Melgaco CA, Araujo MT, Ruellas AC. Applicability of three tooth size prediction methods for white Brazilians. Angle Orthod 2006; 76(4):644-9.
25. Jaiswal AK, Paudel KR, Shrestha SL, Jaiswal S. Prediction of space available for unerupted permanent canine and premolars in a Nepalese population. J Orthod 2009; 36(4):253-9. doi: 10.1179/14653120723283.
26. Arslan SG, Dildeş N, Kama JD, Genç C. Mixed-dentition analysis in a Turkish population. World J Orthod 2009; 10(2):135-40.
27. Mitter M, Dua VS, Wilson S. Reliability of permanent mandibular first molars and incisors widths as predictors for the width of permanent mandibular and maxillary canines and premolars. Contemp Clin Dent 2012; 3(Suppl 1):S8-S12. doi: 10.4103/0976-237X.95094.
28. Srivastava B, Bhatia HP, Singh R, Singh AK, Aggarwal A, Gupta N. Validation of Tanaka and Johnston's analysis in western UP Indian population. J Indian Soc Pedod Prev Dent 2013; 31(1):36-42. doi: 10.4103/0970-4388.112405.
29. Kommineni NK, Reddy CVS, Chandra NS, Reddy DSR, Kumar AK, Reddy MVC. Mixed dentition analysis - Applicability of two non-radiographic methods for Chennai school children. J Int Soc Prev Community Dent 2014; 4(2):133-8. doi: 10.4103/2231-0762.139847.
30. Mahmoud BK, Abu Asab SH, Taib H. Accuracy of four tooth size prediction methods on Malay population. ISRN Dent 2012; 2012:523703. doi: 10.5402/2012/523703.