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A Comparison of Four Different Methods of Prediction of Mesiodistal Widths of Unerupted Permanent Canines and Premolars

Waqar Jeelani
Department of Orthodontics, Faculty of Dentistry, Bakhtawar Amin Medical and Dental College, Multan, Pakistan, wjeelani@gmail.com

Washma Asad
Department of Orthodontics, Faculty of Dentistry, Shahbaz Sharif District Hospital, Multan, Pakistan

Maheen Ahmed
Department of Orthodontics, Faculty of Dentistry, Bakhtawar Amin Medical and Dental College, Multan, Pakistan

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ORIGINAL ARTICLE

A Comparison of Four Different Methods of Prediction of Mesiodistal Widths of Unerupted Permanent Canines and Premolars

Waqar Jeelani[*1], Washma Asad[2], Maheen Ahmed[1]

[1]*Department of Orthodontics, Faculty of Dentistry, Bakhtawar Amin Medical and Dental College, Multan, Pakistan*
[2]*Department of Orthodontics, Faculty of Dentistry, Shahbaz Sharif District Hospital, Multan, Pakistan*
[*]*Correspondence e-mail to: wjeelani@gmail.com*

ABSTRACT

The success of orthodontic treatment depends upon the accurate assessment of mesiodistal widths of unerupted canines and premolars in mixed dentition stage. There are several methods available for mixed dentition analysis with dubious reliability in our population. **Objective:** To statistically develop new prediction equations for Pakistani subjects to predict the widths of unerupted upper canines and premolars (U345) and lower canine and premolars (L345) using mesiodistal widths of lower incisors (I_1I_2) and lower incisors and first molars ($I_1I_2M_1$) and compare their performance with previously established methods of Moyers and Tanaka-Johnston. **Methods:** Study was conducted using the data from the dental casts of 200 Pakistani subjects with permanent teeth. Linear regression analysis was used to develop general and gender specific equations for estimation of U345 and L345 using the combined mesiodistal width I_1I_2 and $I_1I_2M_1$. The actual and estimated sum of of U345 and L345 as determined by Moyers and Tanaka-Johnston and those from prediction equations based on I_1I_2 and $I_1I_2M_1$ were compared using the paired sample t-test. **Results:** There were signficant differences in the actual mesiodistal widths of U345 and L345 and those calculated using Tanaka-Johnston and Moyers methods. Newly developed equations based on I_1I_2 and $I_1I_2M_1$ performed better than the Moyers and Tanaka-Johnston methods in both the arches. **Conclusion:** Moyers and Tanaka-Johnston analyses generally overestimated U345 and L345 dimensions. The newly developed prediction equations based on I_1I_2 and $I_1I_2M_1$ performed better for the prediction of mesiodistal widths of U345 and L345.

Key words: dental arch, mixed dentition, transitional dentition

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INTRODUCTION

Interceptive orthodontics deals with the diagnosis and management of developing malocclusion in a growing patient.[1] The simple and inexpensive interceptive procedures are effective in improving the severity of malocclusion during mixed dentition stage.[2] Mixed dentition stage comprises of both erupting permanent and exfoliating primary teeth. The cumulative size of all permanent teeth is greater than that of the deciduous dentition.[3,4] Several biological mechanisms exist to cater this discrepancy in size of deciduous and permanent teeth.[4] Moreover, interceptive orthodontic therapies such as expansion, serial tooth extractions, space regaining appliances may be employed to improve the severity of the developing malocclusion.[1] To improve the likelihood of success of these procedures, it is essential to accurately predict the size of the unerupted permanent teeth.

In the past, several mixed dentition analyses have been proposed.[5,11] These analyses can be broadly classified as those requiring radiographs and those which are based on prediction tables and equations. The radiographic aids such as perapical radiographs, cephalograms and computed tomography may be utilized to accurately predict the size of the unerupted teeth.[5,6] However, the radiographic methods are time consuming and lead to undue radiation exposure to young patients. The advantage of prediction equation and proportionality tables is that they are quick and do not require radiation exposure. These methods commonly utilize the mesiodistal widths of the mandibular incisors to predict the size of the unerupted canines and premolars.[7-14]

The proportionality tables, though useful, may not be generalized to all populations as their values are derived from a specific population groups with certain dental characteristics. Sholapurmath et al[15], Namitha et al[16] and Brito et al[17] reported significant differences between the actual and predicted arch widths using the Tanaka and Johnston method in their populations. Memon and Fida[18] in their study compared the three different mixed dentition analyses based on the mandibular incisor values. They found Moyers[7] and Flores-Mir[9] method to be less reliable as compared to the Tanaka and Johnston method. Tayyab et al[19] also found Moyer's method to be less accurate in a sample of Pakistani population. In 2007, Melgaco et al[12] proposed the utilization of permanent first molars along with the mandibular incisors dimensions to improve the predictability of the size of the unerupted teeth. They statistically determined a prediction equation to predict the value of unerupted canine and premolars in Brazilian population that showed a high correlation with the actual value. Brito et al[17] also verified that the prediction equation model based on the first molars and incisors is generally more accurate. On the other hand, the Moyers and Tanaka-Johnston methods overestimated the size of unerupted teeth in their sample.

The mixed dentition analysis is an important parameter that decides the effectiveness of the interceptive treatment for any patient. As the tooth size may vary due to gender, population etc., the prediction equations and proportionality tables are most accurate for the population from which the sample is derived.[10,15,16,18,19] To our knowledge, multiple studies the validity of Moyers[7] and Tanaka-Johnston[8] methods have been reported for Pakistani population that has shown contradictory results.[18-23] This study was aimed to statistically determine the prediction equation based on the values of mandibular molars and incisors using the Melgaco[12] method to predict the widths of unerupted canines and premolars. Moreover, this may eliminate the need for unwarranted radiation exposure in young children and significantly reduce the cost associated with the use of radiographic imaging and later comprehensive orthodontic treatment.

METHODS

A cross-sectional study was conducted using the data from the dental casts, poured in orthodontic stone (Elite Ortho, Zhermack, Badia Polesine, Italy), of 200 Pakistani subjects (100 males and 100 females) aged 12-30 years with permanent teeth including the first molars were included in the study. Subjects with any missing or extracted teeth, dental prosthesis, proximal restorations, pathologies, previous orthodontic treatment or history of facial/dental trauma were excluded. The sample size was calculated using the findings of Memon and Fida[18] who reported the mean values of actual sum of lower canine and premolars as 20.30 ± 1.30 mm and estimated sum of lower canine and premolars as 21.09 ± 2.42 mm. The power was kept at 80% and alpha as 0.05 for sample calculation which gave us a minimum sample size of 87 subjects in each group. This number was inflated to 100 subjects in each group to further improve the power of the study. This resulted in a total sample of 200 subjects meeting the aforementioned criteria.

A digital vernier caliper (Song Young International, Taiwan, China) was used to measure the mesiodistal widths of permanent teeth from right side first molar to the left side molar by the principal investigator. To avoid positional error in placement of the measuring instrument, the following standardized protocol was utilized; the measuring instrument was placed perpendicular to the long axis of the tooth and parallel to the occlusal plane and the widest mesiodistal dimension was measured up to one tenth of a millimeter.

The following were calculated: I_1I_2 = Sum of mesiodistal widths of right and left mandibular incisors; $I_1I_2M_1$ = Sum of mesiodistal widths of right and left mandibular molars and incisors; Actual U345 = Sum of mesiodistal widths of permanent maxillary canine, first and second premolars (U345) as measured on the dental cast; Actual L345 = Sum of mesiodistal widths of permanent mandibular canine, first and second premolars (L345) as measured on the dental cast; Estimated U/L 345 - Moyers = Estimated width of U345 and L345 using the sum of mesiodistal widths of mandibular incisors as correlated from the Moyers[7] prediction table; Estimated U/L 345 - Tanaka-Johnston = Estimated width of U345 and L345 using the sum of mesiodistal widths of mandibular incisors as calculated using the Tanaka-Johnston[8] equation

Statistical analysis

Data was analyzed using the Statistical Package for Social Science version 20.0 for Windows (SPSS Inc., Chicago, Illinois USA). Twenty dental casts were randomly selected and re-measured by the principal investigator to determine the intra-examiner reliability. The intra-examiner correlation coefficients (ICC) were calculated for each measurement which were greater 0.934 showing a high degree of intra-examiner reliability. Independent sample t-test was used to compare the mesiodistal widths between males and females. The actual and estimated sum of mesiodistal widths of U345 and L345 as determined by Moyers[7] and Tanaka-Johnston[8] prediction tables were compared using the paired sample t-test. Linear regression analysis was used to develop equations for estimation of U345 and L345 using the combined mesiodistal width of lower incisors only and combined mesiodistal width of lower incisors and first molars. The following regression equation was used: $Y = a + bx$; where Y (dependent variable) equals the predicted sum of permanent canines and premolars on both sides and x (independent variable) equals the sum of mesiodistal widths of selected erupted teeth on both sides. Whereas,

Table 1. Comparison of mesiodistal tooth dimensions between male and female subjects

Tooth	Male Mean ± SD (mm)	Female Mean ± SD (mm)	Mean Difference (mm)	p
RU6	10.58±0.90	10.13±0.94	0.452	0.001
RU5	7.08±0.73	6.66±0.68	0.420	0.001
RU4	7.10±0.76	6.87±0.81	0.235	0.037
RU3	8.55±0.86	7.84±0.79	0.711	0.001
RU2	7.12±0.77	6.94±0.77	0.184	0.096
RU1	8.90±0.99	8.34±1.02	0.560	0.001
LU1	8.99±1.02	8.36±1.00	0.634	0.001
LU2	7.25±0.67	7.08±0.89	0.170	0.132
LU3	8.41±0.96	7.84±0.64	0.576	0.001
LU4	7.27±0.99	6.82±0.66	0.449	0.001
LU5	7.01±0.83	6.64±0.72	0.369	0.001
LU6	10.64±0.79	9.86±1.75	0.788	0.001
RL6	10.73±1.13	10.57±1.00	0.160	0.293
RL5	7.23±0.64	6.96±0.93	0.268	0.019
RL4	7.29±0.88	6.91±0.66	0.382	0.001
RL3	7.52±0.81	7.09±0.73	0.420	0.001
RL2	6.57±0.73	6.37±0.75	0.202	0.057
RL1	6.31±1.17	6.16±0.96	0.1556	0.308
LL1	6.16±1.17	6.02±0.90	0.142	0.340
LL2	6.52±0.86	6.29±0.73	0.225	0.049
LL3	7.54±0.74	7.29±0.89	0.254	0.031
LL4	7.23±0.78	7.01±0.71	0.220	0.040
LL5	7.25±0.90	6.98±0.71	0.270	0.020
LL6	10.75±1.05	10.38±0.95	0.362	0.012

Independent sample t-test; mm: millimeters; SD: standard deviation

a and b are constants. A p-value of less than 0.05 was considered statistically significant.

RESULTS

The total sample comprised of 100 males and 100 female subjects. The mean age of the sample was 21.07 ± 6.67 years. The mean mesiodistal width of each tooth was compared between male and female sample using independent sample t-test (Table 1). The results showed that the mesiodistal tooth width of male sample was significantly greater than that in female sample ($p<0.05$). Based on this finding, further results were stratified according to gender.

The combined mesiodistal width of U345 and L345 were compared with those calculated using Tanaka-Johnston's analysis and Moyers method using paired sample t-test. The results showed that there was significant difference between the actual and estimated values through these methods (Table 2 and 3).

Furthermore, we used linear regression analysis to develop equations for estimation of U345 and L345 using the combined mesiodistal width of lower incisors (I_1I_2) only and combined mesiodistal width of lower incisors and first molars ($I_1I_2M_1$).

The results were generated separately for male and female sample. The prediction equations based on sum of mesiodistal width of lower incisors and first molars ($I_1I_2M_1$) are: Sum of Upper 345 (For total sample) = 8.75 + 0.286 (Sum of $I_1I_2M_1$); Sum of Upper 345 (For males) = 7.26 + 0.329 (Sum of $I_1I_2M_1$); Sum of Upper 345 (For females) = 12.36 + 0.196 (Sum of $I_1I_2M_1$); Sum of Lower 345 (For total sample) = 6.51 + 0.328 (Sum of $I_1I_2M_1$); Sum of Lower 345 (For males) = 4.52 + 0.372 (Sum of $I_1I_2M_1$); Sum of Lower 345 (For females) = 9.05 + 0.270 (Sum of $I_1I_2M_1$)

Table 2. Comparison of actual and estimated combined mesiodistal width of upper canine, first premolar and second premolar (U345)

Gender	Combined mesiodistal width of upper canine, first premolar and second premolar (U345)					Mean Difference Mean ± SD (mm)	p
	Actual Mean ± SD (mm)	By Tanaka-Johnston Mean ± SD (mm)	By Moyers Method Mean ± SD (mm)	By $I_1I_2M_1$ Equation Mean ± SD (mm)	By I_1I_2 Equation Mean ± SD (mm)		
Male (n=100)	22.72 ± 2.27	23.62 ± 1.77				0.90 ± 1.41	0.000*
	22.72 ± 2.27		23.54 ± 2.41			0.82 ± 1.97	0.007*
	22.72 ± 2.27			22.74 ± 1.35		0.02 ± 0.74	0.890
	22.72 ± 2.27				22.60 ± 0.69	0.12 ± 0.37	0.437
Female (n=100)	21.34 ± 1.72	22.42 ± 2.41				1.20 ± 1.89	0.000*
	21.34 ± 1.72		21.93 ± 0.87			0.59 ± 1.63	0.000*
	21.34 ± 1.72			21.89 ± 0.97		0.55 ± 0.81	0.001*
	21.34 ± 1.72				22.06 ± 0.47	0.72 ± 1.66	0.000*
Total (N=200)	22.03 ± 2.12	23.02 ± 1.62				0.99 ± 2.22	0.000*
	22.03 ± 2.12		22.73 ± 2.12			0.70 ± 2.39	0.000*
	22.03 ± 2.12			22.91 ± 1.15		0.88 ± 1.08	0.000*
	22.03 ± 2.12				21.64 ± 0.68	0.39 ± 0.84	0.007*

Paired sample t-test; * $p<0.05$; mm: millimeters; SD: standard deviation

Table 3. Comparison of actual and estimated combined mesiodistal width of lower canine, first premolar and second premolar (L345)

Gender	Combined mesiodistal width of lower canine, first premolar and second premolar (L345)					Mean Difference Mean ± SD (mm)	p
	Actual Mean ± SD (mm)	By Tanaka-Johnston Mean ± SD (mm)	By Moyers Method Mean ± SD (mm)	By $I_1I_2M_1$ Equation Mean ± SD (mm)	By I_1I_2 Equation Mean ± SD (mm)		
Male (n=100)	22.03 ± 1.96	23.28 ± 1.77				1.25 ± 1.69	0.000*
	22.03 ± 1.96		22.79 ± 1.30			0.76 ± 1.55	0.000*
	22.03 ± 1.96			21.86 ± 1.53		0.17 ± 1.07	0.607
	22.03 ± 1.96				21.77 ± 1.18	0.26 ± 0.59	0.070
Female (n=100)	21.42 ± 2.20	22.92 ± 1.45				1.50 ± 2.11	0.000*
	21.42 ± 2.20		22.45 ± 1.79			1.03 ± 2.25	0.000*
	21.42 ± 2.20			22.26 ± 1.03		0.84 ± 1.92	0.000*
	21.42 ± 2.20				22.41 ± 0.79	0.01 ± 0.67	0.912
Total (N=200)	21.73 ± 2.10	23.10 ± 1.62				1.37 ± 1.91	0.000*
	21.73 ± 2.10		22.62 ± 1.54			0.89 ± 1.93	0.000*
	21.73 ± 2.10			21.33 ± 1.32		0.40 ± 1.21	0.008*
	21.73 ± 2.10				21.99 ± 1.04	0.26 ± 1.95	0.035*

Paired sample t-test; * $p<0.05$; mm: millimeters; SD: standard deviation

The prediction equations based on sum of mesiodistal width of lower incisors (I_1I_2) only are: Sum of Upper 345 (For total sample) = 16.72 + 0.211 (Sum of I_1I_2); Sum of Upper 345 (For males) = 17.71 + 0.196 (Sum of I_1I_2); Sum of Upper 345 (For females) = 16.90+ 0.179 (Sum of I_1I_2); Sum of Lower 345 (For total sample) = 13.60 + 0.322 (Sum of I_1I_2); Sum of Lower 345 (For males) = 13.60 + 0.330 (Sum of I_1I_2); Sum of Lower 345 (For females) = 14.08 + 0.295 (Sum of I_1I_2).

For validation of our prediction equations, the sum of actual U345 and actual L345 were calculated for the

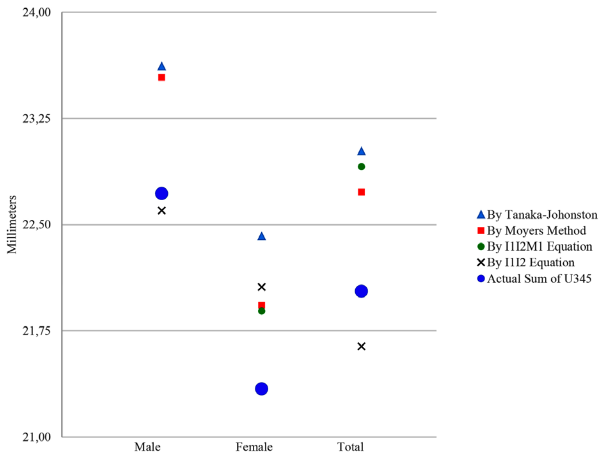

Figure 1. Comparison of four different methods for the assessment of U345

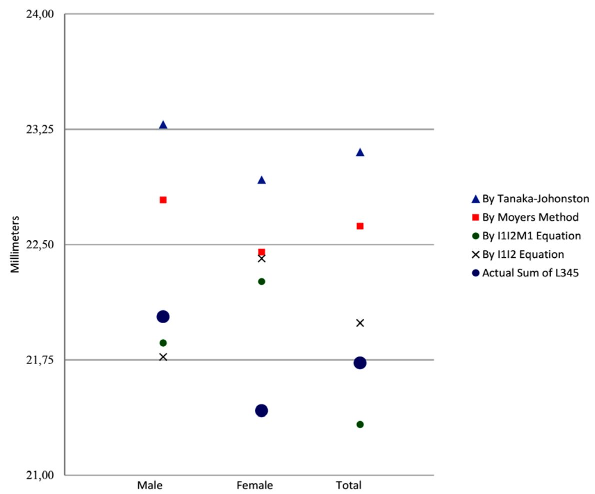

Figure 2. Comparison of four different methods for the assessment of L345

sample of 30 female and 30 male subjects. These were then compared to the corresponding values derived from the newly developed prediction equations. The newly developed gender specific and general equations were used separately to calculate estimated values of U345 and L345. The mean differences in the actual and calculated values were calculated and reported in Table 2 and 3. The newly developed equations based on I_1I_2 and $I_1I_2M_1$ performed better than the Moyers[7] and Tanaka-Johnston[8] methods (Figure 1 and 2).

DISCUSSION

Mixed dentition analysis is essential to assess the adequacy of the available space to accommodate the erupting teeth. An ideal analysis should be simple, easy to apply, cost effective and non- invasive. Most importantly, it should be able to accurately predict the arch length discrepancy as the prognosis of the orthodontic treatment and mechanics strongly rely on this. The radiographic methods based on three dimensional imaging may be considered the most accurate but has the disadvantage of radiation exposure and cost associated with it. The non-radiographic methods are usually based on certain population groups, hence are usually accurate only for the population from which the sample is derived. This study was conducted to determine the most accurate mixed dentition analysis model applicable to a sample derived from Pakistani population.

Males generally show a trend towards increased physical dimensions as compared to the females. This is applicable to the tooth size as well.[3,5,7-9,12,14,18] In the present study, males generally showed an increased tooth size as compared to the females, therefore the further results were stratified. The Moyers[7] and Tanaka-Johnston[8] analyses are the most commonly used analyses as they are simple, safe and cost effective. These methods utilize the widths of the permanent mandibular incisors to predict the widths of the unerupted teeth. Tayyab et al[19] in their study on a sample of Pakistani population evaluated the applicability of Moyers[7] prediction table. Based on their findings, the analysis was found to be inaccurate for our subset of population. Brito et al[17] compared the actual and estimated width of mandibular canine and premolars only using both the Moyers[7] and Tanaka-Johnston[8] methods on a subset of Brazilian population. They found the estimated widths to be larger as compared to the actual mesiodistal widths measured on the cast. Similar findings were reported by Bugaighis et al[24] and Paredes et al[25] which are in concordance with the results our study.

In order to improve the predictability of the estimated size of unerupted permanent teeth, new prediction equations based on the mesiodistal widths of both the mandibular incisors and molars was proposed by Melgaco et al.[12] They proposed that this combination of teeth was found to be more accurate for predicting the width of the unerupted teeth as compared to the previous method using the mesiodistal widths of the mandibular incisors only. In the present study, the applicability of this modified model was evaluated on our subset of population.

In the current study, two methods were developed one of which was based on lower incisors only and the other involved lower incisors as well as lower first molars. We compared the estimated widths of U345 determined from these four analyses with the actual widths of the upper premolars and canines. For the maxillary arch, newly developed equations based on I_1I_2 and $I_1I_2M_1$ performed better than the Moyers[7] and Tanaka-Johnston[8] methods.[26] The gender specific equations for males showed no significant difference in the actual and the predicted Sum of U345. A measure reason for the inaccuracy of Moyer's and Tanaka-Johnston's methods may be the fact that the Moyers[7] and Tanaka-Johnston[8] analyses are based on a certain set of population and specific permanent teeth i.e. mandibular incisors. As tooth size varies with race, ethnicity and gender, hence these may not be generalizable to all.

For the estimation of sum of L345, the accuracy of all the four methods were assessed for total sample as well as male and female samples, separately (Table 3). The results again show that the Tanaka-Johnston's and Moyer's methods consistently overestimated the tooth size which is in concordance with the results reported in previous studies.[17,19,21,22] Though the results of our general equations were better than these two methods but gender specific equations performed far better in the assessment of sum of L345.

The quality of orthodontic treatment depends on accurate diagnosis. Many vital decisions such as extractions of permanent teeth for orthodontic purposes depends on the space analyses. The current study offers two new prediction equations for the mixed dentition analysis which perform better than the previously used methods reported in literature. The use of these equations is recommended for Pakistani subjects in mixed dentition stage for better treatment planning and predictable therapeutic outcome.

CONCLUSION

Based on the findings of the current study it is concluded that the Moyers and Tanaka-Johnston analyses generally overestimated the combined mesiodistal width of both maxillary and mandibular premolars and canines. Prediction equations based on mesiodistal widths of lower incisors only and on lower incisors and first molars from the local population performed better for the prediction of combined mesiodistal widths of maxillary and mandibular premolars and canines. For the estimation of combined mesiodistal widths of lower premolars and canines, the gender specific equations developed in the current study should be utilized for more accurate results.

CONFLICT OF INTERESTS

Authors declare that they have no conflict of interest.

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