Original Article

Prediction of the size of unerupted permanent canines and premolars in a Qatari sample

ABSTRACT

Aim: The purpose of this investigation was to establish an equation for the prediction of the size of unerupted canines and first and second premolars in a Qatari population.

Materials and Methods: In this study, dental casts of 100 Qataris (50 males and 50 females) were selected. The participants' age ranged from 15 to 20 years. The width of all permanent teeth with the exception of second and third molars was measured. The data were subjected to Student's *t*-test and regression analysis.

Results: The results indicated that 15%, 25%, and 35% confidence levels were more accurate determinants of the unerupted canines and premolars than the commonly used 75% level of Moyers when both sexes were combined. The multiple regression equations revealed different confidence levels for males and females. Tanaka and Johnston's equations overestimate the predicted tooth width of the unerupted canine and first and second premolars.

Conclusions: Three levels of confidence were found to be more accurate in the maxillary arch and two in the mandibular arch when compared to the commonly used 75% in Moyers' table when both sexes were combined. Therefore, three new equations for maxillary and mandibular arches are proposed to predict the size of unerupted canine and first and second premolar teeth for Qatari males and females and for both sexes combined.

Keywords: Moyer's prediction, Tanaka and Johnston equation, Qatari

INTRODUCTION

Orthodontic treatment has its goal as the enhancement of esthetics and function. Most patients, however, present for esthetic reasons. Information pertaining to tooth width, shape, alignment, and rotation can all be obtained from a dental cast as can be the presence or absence of teeth, arch form and symmetry, arch width, and occlusal relationship.

The dental cast is still considered a vital diagnostic tool.[1] Significant differences in occlusal harmony can lead to malocclusion and pose an obstacle to attaining a Class I canine and molar relationship, optimal overjet and overbite.[2,3] A discrepancy in tooth width has been implicated in the etiology of malocclusion. While the vast majority of natural teeth exhibit harmony in their relative widths, approximately 5% of individuals in populations studied have displayed a degree of divergence from this harmony in tooth width.[4]

Variations in the size and shape of teeth are genetically determined.[5,6] The genetic basis for this variation is best explained by the polygenic model of inheritance. Lundström[7]

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carried out a comparison of 97 pairs of like-sex monozygotic and dizygotic twins. He observed a strong correlation in tooth size between monozygotic twins and concluded that the tooth size is determined to a large extent by genetic factors.

Several methods have been introduced to predict the size of unerupted teeth.[8,9] The most common method among these is Moyers' analysis.[10] Moyers formulated probability tables which predicted the amount of space required to align the permanent canines and premolars by utilizing the sum of the width of the four mandibular permanent incisors.

In addition, Tanaka and Johnston[9] formulated predictive equations which yield similar values to Moyers' table. These equations are widely used as an alternative to Moyers' tables.

al-Khadra[11] carried out a study on 100 Saudi individuals who were randomly selected from among patients attending the orthodontic clinic of the College of Dentistry at King Saud University. He reported that the 35% level was more accurate determinant than the commonly used 75% confidence level. Further, he found that the Tanaka and Johnston prediction equations overestimated the measurements of buccal segments in the Saudi population studied. He concluded that the data highlighted the limitation of these methods when applied to Saudi populations and proposed two linear regression equations for predicting tooth size in Saudis.

Hashim and Al-Shalan[12] conducted a study on Saudi patients from which they derived a new formula to predict the size of unerupted canines and premolars. They reported that the 50% level was a more accurate determinant of the cuspids and bicuspids width than the commonly used 75% level when both sexes were combined. In addition, they found that the 75% and 65% confidence levels were appropriate for predicting maxillary and mandibular tooth width for cuspids and bicuspids, respectively. On the other hand, for females, 65% is the accurate level of confidence for the sum of all values for maxillary and mandibular tooth width of cuspids and bicuspids, whereas for large values, the 75% level is the accurate level.

Buwembo and Luboga[13] tested the applicability of the Tanaka and Johnston equation and Moyers' prediction table on a Ugandan population. They noted that the Tanaka and Johnston[9] equation overestimated the mesiodistal tooth widths, whereas the Moyers'[3] tables could be used at different percentile levels for both sexes.

Diagne *et al*.[14] concluded from their study on a Senegalese population that the Moyers'[3] prediction tables and Tanaka and Johnston[9] equations were not applicable and introduced new prediction equations.

Likewise, Schirmer and Wiltshire[14] reported from their study on a Black South African population that the Moyers'[3] prediction tables were not applicable and proposed new prediction tables. They went on to conclude that there is inconclusive evidence in support of the applicability of the Tanaka and Johnston[9] equation and Moyers'[3] tables to populations of African descent.

Ngesa[15] stated that "both the Tanaka and Johnson equation and Moyers' prediction tables use the four permanent mandibular incisors as the predictor teeth to estimate the combined mesiodistal tooth widths of the unerupted permanent canine and premolars in one quadrant. This is due to the fact that they appear early during the mixed dentition period, are easy to measure both in the mouth and on dental casts, and are less prone to morphological changes."

Shobha *et al*.[16] carried out an observational randomized, cross-sectional study of 900 patients from the Southeastern Region of Andhra Pradesh, India, with the age ranging from 13 to 15 years without sex predilection. In light of finding significant deviation from the Tanaka and Johnston equation and Moyers' tables both at 50 and 75 percentiles, they concluded that the applicability of these predictors to the population studies was limited and proposed a new regression equation.

Tikku *et al*.[17] reported on a study of 200 dental casts obtained from North Indian patients and students. The sample was equally divided by gender and had an average age of 20.12 ± 4.70 years for males and 19.54 ± 3.16 years for females. Their results confirmed the existence of racial variation in tooth size, and the effectiveness of the proposed regression equation in size prediction.

Al-Kabab *et al*.[18] compared Moyers' method with a predictive regression equation that they formulated for the size of unerupted permanent canines and molars on a Yemeni population. Following Moyers' method, they formulated new probability tables and concluded that significant differences ($P < 0.05$) were found when this equation was applied versus the result obtained using Moyers' tables at almost all percentile levels, including the recommended 50% and 75% levels.

Bhatnagar *et al*.[19] conducted a study on children in the city of Aligarh in which they evaluated the applicability of Moyers' mixed dentition analysis at the 75th percentile in predicting the size of permanent canines and premolars. A total of 60 pairs of study casts (30 males and 30 females) were used for gathering the data. They concluded that Moyers' mixed dentition analysis overestimates the mesiodistal width of canines and premolars in both the sexes.

Mubeen *et al*.[20] performed an odontometric study on 100 dental casts of Class II division 1 patients that were collected after sample size calculation. The predicted mesiodistal width of unerupted canines and premolars was determined using the Melgaço *et al.*[21] equation. They found a significant correlation ($P < 0.001$) between the predicted and actual mesiodistal widths of canines and premolars along with terms of gender stratification. Accordingly, they concluded that the Melgaco equation correlates positively with the actual mesiodistal width of teeth in both genders of Class II division I malocclusion with females having a higher correlation coefficient.

Giri *et al*.[22] sought to assess the applicability of the Moyers' and Tanaka–Johnston analyses to a population of Nepalese mongoloids and to develop predictive equations applicable to this population if indicated. The sample size consisted of 100 pretreatment study casts (50 males and 50 females). They concluded that both Moyers' and Tanaka–Johnston analyses were not accurate predictors of mesiodistal widths for unerupted canines and premolars for this population and proposed a new prediction equation. They pointed out the need to confirm the applicability and accuracy of their proposed regression equation on a larger sample size.

The literature review did not reveal a study having been conducted on a population of Qatari patients. Hence, the intention of the present investigation was to assess the applicability of both the Tanaka and Johnston equations and Moyers' analysis to such a population. Contingent upon the findings, the study could proceed to the formulation of an equation to predict the size of unerupted canines and premolars in the Qatari population studied. Findings would be compared to those of al-Khadra *et al.*

MATERIALS AND METHODS

Orthodontic dental casts were made from patients seeking orthodontic treatment at Hamad Dental Center. A total of 100 patients equally divided by gender were selected based on the following criteria:

- All patients were natives of Qatar
- Age ranged from 15 to 20 years
- Molar and canine teeth in Class I relationship with normal overjet and overbite
- Absence of crowding, spacing, tooth rotation, or dental restorations (with the exception of Class I fillings)
- No previous history of orthodontic treatment
- Study cast free of flaws.

Figure 1: Digital caliper used for measuring tooth width

Figure 2: Central incisor measurement

Figure 3: The upper first molar measurement

Study cast measurements

Measurements were made directly on unsoaped casts under a combination of natural and neon lighting. An electronic digital caliper [Figure 1] (Digimatic calipers, Mitutoyo, UK) was used to record the mesiodistal tooth width from the right permanent first molar to the left permanent first molar for the maxilla and mandible.

The technique described by Hunter and Priest[23] was used for making the measurements. The caliper beaks were inserted through the buccal vestibule and aligned with the long axis of the tooth. The beaks were then closed until gentle contact was made with the contact points of the tooth. The measurements included the mesiodistal width of all the 12 maxillary and mandibular teeth from the right first permanent molar to the left first permanent molar. Care was taken during the recordings to avoid damage to the casts [Figures 2 and 3].

Error of the method

Ten orthodontic casts were randomly selected and measured by one of the coauthors (HA). The measurements were repeated after an interval on 1 week. No statistically significant difference in the recordings was found according to Student's *t*-test.

Student's *t*-test using a level of significance (OR: revealed a level of significance) of $P < 0.05$ was used to compare the data gathered for males and females. It was also used to compare the findings with values calculated from Moyers' and Tanaka and Johnston equations, as well as the equations derived by al-Khadra from his study on a Saudi population.

Regression equations were proposed for predicting tooth size in a Qatari population. Equations were formulated as follows:

Linear regression equation:

$Y = b(x) + a$

Y = The predicted size of the canines; first and second premolars in a quadrant in millimeters.

X = The width of the four permanent mandibular incisors in millimeters.

A and B are the estimated regression constant and regression coefficient, respectively

Multiple regression equations were formulated which included gender as a variable:

$Y = A + B(X1) + C(X2)$ where

- X1 is the measured width of the four permanent mandibular incisors in millimeters
- X2 is a dummy variable which takes the value 1 for male and 0 for female
- B and C are partial regression coefficients.

Significant differences were observed when the sex factor was included in both jaws.

RESULTS

When the data were subjected to regression analysis, the following equations were obtained for predicting the size of maxillary and mandibular cuspids and first and second bicuspids in Qatari nationals:

- Combined (male and female)
  - i. Maxillary $Y = 0.444 (x) + 10.973$
  - ii. Mandibular $Y = 0.566 (x) + 7.899$
- Male
  - i. Maxillary $Y = 0.432 (x) + 11.435$
  - ii. Mandibular $Y = 0.543 (x) + 8.726$
- Female
  - i. Maxillary $Y = 0.359 (x) + 12.644$
  - ii. Mandibular $Y = 0.461 (x) + 9.959$

where

Y = The mesiodistal tooth width of the cuspids and first and second bicuspids in one buccal segment in millimeters.
X = The measured width of the four permanent mandibular incisors in millimeters.

Tables 1 and 2 show the difference between the results of the present study and those reported by al-Khadra or obtained from the Tanaka and Johnston equations. The latter values were consistently higher than the results of the present study.

Tables 1 and 2 also illustrate that the measurements recorded from of the present study were significantly closer to Moyers' table at the 35% confidence level when the sum of the lower incisors was small (<20.5 mm) and at the 15% and 25% levels when the sum of the lower incisors was >21 mm in the maxillary buccal segment.

Tables 3 and 5 show the results of the present study in the maxillary arch for males and females respectively. The results show that the figures for males were closer to the 35% confidence level when the sum of the lower incisors was <23 mm and at 25% when the sum was higher.

In contrast, the measurements for females were close to the 15% confidence level when the sum of the lower incisors was >22 mm and at 25% as well as 35% when the sum of lower incisors was <21.5 mm.

Table 1: Predicted tooth width of maxillary unerupted canines and premolars for Qatari males and females combined Moyers' study, Tanaka and Johnston equation, and al-Khadra study among Saudi sample

Sum of lower incisor	Present study (*n*=100)	Moyers' prediction			Tanaka and Johnston	al-Khadra Saudi sample (*n*=34)
		35%	25%	15%		
19.5	19.6	19.6*	19.4	19.0	20.8	19.5
20.0	19.9	19.9*	19.7	19.3	21.0	19.8
20.5	20.1	20.2*	19.9	19.6	21.3	21.1
21.0	20.3	20.5	20.2*	19.9	21.5	20.4
21.5	20.5	20.8	20.5*	20.2	21.8	20.7
22.0	20.7	21.0	20.8*	20.4	22.0	21.1
22.5	21.0	21.3	21.0*	20.7	22.3	21.4
23.0	21.2	21.6	21.3*	21.0	22.5	21.7
23.5	21.4	21.9	21.6	21.3*	22.8	22.0
24.0	21.6	22.1	21.9	21.5*	23.0	22.3
24.5	21.9	22.4	22.1	21.8*	23.3	22.6
25.0	22.1	22.7	22.4	22.1*	23.5	23.0

Maxillary y=0.444 (x) + 10.973

Table 2: Predicted tooth width of Mandibular un-erupted canines and premolars for Qatari males and females combined Moyer's study, Tanaka and Johnston equation and AL-Khadra study among Saudi sample

Sum of lower incisor	Present study (*n*=100)	Moyer's prediction			Tanaka and Johnston	al-Khadra Saudi sample (*n*=34)
		35%	25%	15%		
19.5	18.9	19.0*	18.7	18.4	20.3	19.3
20.0	19.2	19.3*	19.0	18.7	20.5	19.6
20.5	19.5	19.6*	19.3	19.0	20.8	19.9
21.0	19.8	19.9*	19.6	19.3	21.0	20.2
21.5	20.1	20.2*	19.9	19.6	21.3	20.4
22.0	20.4	20.5*	20.2	19.8	21.5	20.7
22.5	20.6	20.8	20.5*	20.1	21.8	21.0
23.0	20.9	21.1	20.8*	20.4	22.0	21.3
23.5	21.2	21.4	21.1*	20.7	22.3	21.5
24.0	21.5	21.7	21.4*	21.0	22.5	21.8
24.5	21.8	22.0	21.7*	21.3	22.8	22.1
25.0	22.1	22.3	22.0*	21.6	23.0	22.4

Mandibular y=0.566 (x) + 7.899

Tables 4 and 6 show the measurements for the mandibular arch for males and female. When compared to the values obtained from Moyers' prediction tables at the 35%, 25%, and 15% levels of confidence, the results of this study for males were closest to the 35% level. In the case of females, on the other hand, values were close to the 15% and 25% levels when the sum of the lower incisors was >20.5 mm and to the 35% level when the measurement was <20 mm.

DISCUSSION

Patients presenting for orthodontic treatment mainly do so as a result of esthetic and/or functional impairment deriving from crowding or spacing or both.[23] Previous studies have found that the dimensions of maxillary and mandibular teeth need to be in harmony with each other to achieve optimal occlusion upon the completion of orthodontic treatment.[7] If significant discrepancy in tooth size exists, orthodontic alignment into optimal occlusion may not be possible.[3] Several investigators have reported the existence of significant discrepancies in tooth size within a large percentage of orthodontic patients. Therefore, the treating orthodontist needs to be aware of the existence of such a discrepancy from the outset.[23-25] There exist several treatment options to deal with this occurrence including the restoration of under-sized teeth, stripping of over-sized teeth, and extraction.

The present study made use of a proposed regression equation to predict the tooth width of permanent canines and premolars in a Qatari population. When the results for the maxillary arch for both sexes were combined, they yielded three levels of confidence: The results in the maxillary arch illustrate that the actual measurements were closer to the Moyers' table at the 35% confidence level when the sum of the lower incisors is <21.5 mm and at 15% and 25% when

Table 3: Predicted tooth width of maxillary unerupted canines and premolars for Qatari males sample, Moyers' study, and Tanaka and Johnston equation

Sum of lower incisor	Present study (*n*=50)	Moyers' prediction			Tanaka and Johnston
		35%	25%	15%	
19.5	19.9	19.6*	19.4	19.0	20.8
20.0	20.1	19.9*	19.7	19.3	21.0
20.5	20.3	20.2*	19.9	19.6	21.3
21.0	20.5	20.5*	20.2	19.9	21.5
21.5	20.7	20.8*	20.5	20.2	21.8
22.0	20.9	21.0*	20.8*	20.4	22.0
22.5	21.2	21.3*	21.0	20.7	22.3
23.0	21.4	21.6	21.3*	21.0	22.5
23.5	21.6	21.9	21.6*	21.3	22.8
24.0	21.8	22.1	21.9*	21.5	23.0
24.5	22.0	22.4	22.1*	21.8	23.3
25.0	22.2	22.7	22.4	22.1*	23.5

Maxillary y=0.432 (x) + 11.435

Table 4: Predicted tooth width of mandibular unerupted canines and premolars for Qatari males sample, Moyers' study, and Tanaka and Johnston equation

Sum of lower incisor	Present study (*n*=50)	Moyers' prediction			Tanaka and Johnston
		35%	25%	15%	
19.5	19.3	19.0*	18.7	18.4	20.3
20.0	19.6	19.3*	19.0	18.7	20.5
20.5	19.9	19.6*	19.3	19.0	20.8
21.0	20.1	19.9*	19.6	19.3	21.0
21.5	20.4	20.2*	19.9	19.6	21.3
22.0	20.7	20.5*	20.2	19.8	21.5
22.5	20.9	20.8*	20.5	20.1	21.8
23.0	21.2	21.1*	20.8	20.4	22.0
23.5	21.5	21.4*	21.1	20.7	22.3
24.0	21.8	21.7*	21.4	21.0	22.5
24.5	22.0	22.0*	21.7	21.3	22.8
25.0	22.3	22.3*	22.0	21.6	23.0

Mandibular y=0.543 (x) + 8.726

Table 5: Predicted tooth width of maxillary unerupted canines and premolars for Qatari females sample, Moyers' study, and Tanaka and Johnston equation

Sum of lower incisor	Present study (*n*=50)	Moyers' prediction			Tanaka and Johnston
		35%	25%	15%	
19.5	19.6	19.6*	19.4	19.0	20.8
20.0	19.8	19.9*	19.7*	19.3	21.0
20.5	20.0	20.2*	19.9	19.6	21.3
21.0	20.2	20.5	20.2*	19.9	21.5
21.5	20.4	20.8	20.5*	20.2	21.8
22.0	20.5	21.0	20.8	20.4*	22.0
22.5	20.7	21.3	21.0	20.7*	22.3
23.0	20.9	21.6	21.3	21.0*	22.5
23.5	21.1	21.9	21.6	21.3*	22.8
24.0	21.3	22.1	21.9	21.5*	23.0
24.5	21.4	22.4	22.1	21.8*	23.3
25.0	21.6	22.7	22.4	22.1*	23.5

Maxillary y=0.359 (x) + 12.644

Table 6: Predicted tooth width of mandibular unerupted canines and premolars for Qatari females sample, Moyers' study, and Tanaka and Johnston equation

Sum of lower incisor	Present study (*n*=50)	Moyer's prediction			Tanaka and Johnston
		35%	25%	15%	
19.5	18.9	19.0*	18.7	18.4	20.3
20.0	19.2	19.3*	19.0	18.7	20.5
20.5	19.4	19.6	19.3*	19.0	20.8
21.0	19.6	19.9	19.6*	19.3	21.0
21.5	19.9	20.2	19.9*	19.6	21.3
22.0	20.1	20.5	20.2*	19.8	21.5
22.5	20.3	20.8	20.5*	20.1*	21.8
23.0	20.6	21.1	20.8	20.4*	22.0
23.5	20.8	21.4	21.1	20.7*	22.3
24.0	21.0	21.7	21.4	21.0*	22.5
24.5	21.3	22.0	21.7	21.3*	22.8
25.0	21.5	22.3	22.0	21.6*	23.0

Mandibular y=0.461 (x) + 9.959

the sum of the lower incisors is >21 mm. On the other hand, in the mandibular arch, the actual measurements were closer at 35% when sum of the lower incisors was <22 mm and at 25% when the sum was >22.5 mm. This result was partially agreed with the results reported by al-Khadra among Saudi Arabians.[11]

A comparison between the predicted tooth width of the unerupted canines and premolars obtained by applying al-Khadra's equations revealed a significant difference between the Saudi sample and the Qatari population in this study. This suggests that al-Khadra's equations are not applicable to Qatari samples, despite both populations deriving from the Gulf region, and intermarriage between tribes from both states being widespread [Tables 8 and 9]. A similar observation was made in Indian populations studied.[16,17,25,26] One possible cause is genetic factors.

Sexual and racial dimorphism in tooth size between different races has long been established.[24,25] As a result of this dimorphism, multiple regression equations have been formulated taking into account the sex factor. The results of the present study in males show that the 35% (for small values <21.2) and 25% (for higher values >21.4) confidence levels are accurate determinants for predicting the tooth width of maxillary canines and premolars. In addition, the results establish that the 35% confidence level is the accurate determinant for predicting the tooth width of mandibular canines and premolars [Tables 2 and 3]. Statistically significant differences were observed when comparing the results for males and females. It follows, therefore, that separate prediction tables should be formulated for each gender for the purpose of predicting the width of unerupted canines and premolars in both jaws. The same finding was reported by Moyers who was the first among several investigators to establish prediction tables [Tables 7 and 8].[3,12,26,27]

In case of females, 25% and 35% confidence levels applied when the sum of the mandibular incisors was low (19.5 mm–21.5 mm) and the 15% level applied when the sum was higher. Three levels of confidence were applicable to the maxillary arch: the 25% and 35% levels applied for lower values (19.5 mm–21.5 mm), whereas the 15% level was a more accurate determinant for higher values.

The results of the present study would seem to suggest that the Tanaka and Johnston[9] prediction equations overestimate the width of canines and premolars. This is in agreement with the findings of al-Khadra in Saudi Arabians,[11] Buwembo and Luboga[13] in Ugandans, and Diagne *et al*. in Senegalese.[14]

The findings of this study confirm those of previous studies in which it was shown that the Tanaka and Johnston equations and Moyers' analysis are not applicable to populations of African and Arab ethnicity.[11-14,28-30]

Six new equations were formulated to assist an orthodontist and a pedodontist in diagnosing and treating Qatari patients. Further studies with large sample sizes are needed to add to the validity of these findings and to establish alternate prediction tables to those of Moyers, applicable to a Qatari population.

CONCLUSIONS

1. Six equations are proposed for predicting the size of unerupted canines and premolars in Qatari patients
2. No single confidence level was found. Instead, three confidence levels (15%, 25%, and 35%) were found to predict the size of unerupted canines and premolars more accurately than the commonly used 75% when both sexes were combined
3. The findings indicate that, in males, the 25% and 35% confidence levels are accurate determinants for predicting the width of maxillary permanent canines and premolars and 35% confidence level for mandibular teeth
4. Three confidence levels were applicable for females. It would appear that the 25% and 35% confidence levels were applicable for lesser measurements of total width of maxillary and mandibular incisors teeth, while the 15% level was more accurate for both arches when the measurements were greater.

Table 7: Comparison between the present study equation and al-Khadra equation on Qatari sample for the maxillary arch and mandibular arches

	Mean	*P*
Maxillary arch		
Present study	21.04	0.0004
al-Khadra study	21.49	Extremely statistically significant
Mandibular arch		
Present study	20.74	0.0084
al-Khadra study	21.08	Very statistically significant

Significant level $P<0.05$

Table 8: Comparison between the Qatari male and female predicted values using the new formula

	Mean	*P*
Maxilla		
Male equation	21.45	0.0003
Female equation	20.97	Extremely statistically significant
Mandible		
Male equation	21.02	0.027
Female equation	20.65	Statistically significant

Significant level $P<0.05$

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Conflicts of interest

There are no conflicts of interest.

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