

Mixed dentition analysis in Libyan schoolchildren

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ABSTRACT

Objectives: The primary aim of the present study was to assess the applicability of Tanaka and Johnston and Moyers' methods of prediction in Libyan subjects and secondary aim was to develop a new prediction method for the examined population if required.

Materials and Methods: The study sample comprised 343 Libyan schoolchildren with age ranged from 12 to 17 years; 169 males age matched with 174 females, all with no craniofacial abnormalities and orthodontically untreated. The mesiodistal (MD) tooth widths were measured and compared with the estimated values derived from Tanaka and Johnston equations and from Moyers' probability tables at 35%, 50% and 75% respectively using Paired *t*-tests. The constants *a* and *b* in the linear regression equation ($y = a + bx$), the correlation coefficient, the coefficient of determination and the standard errors of estimate were computed.

Results: Significant sexual dimorphism in lower incisors mesiodistal width was observed. There were significant discrepancies between the current measurements and those estimated from Tanaka and Johnston's equation and Moyers' tables. New linear regression equations were derived for both sexes to allow precise prediction for Libyan subjects. The correlation coefficients between the total MD width of the mandibular permanent incisors and that of the maxillary and mandibular canines and premolars were found to be 0.66 and 0.68 for males and 0.57 and 0.58 in females, respectively.

Conclusions: It appears that there is a limitation in the application of Tanaka and Johnston's equation and Moyers' methods to Libyan subjects. The developed prediction equation is more accurate for predicting the MD widths of unerupted canine and premolars of Libyan population.

Key words: Libyan, mixed dentition analysis, prediction equations, probability tables, schoolchildren

INTRODUCTION

Mixed dentition analysis is the prediction of the sum of the size of unerupted permanent canine and premolars (Σ CPP), allowing calculation of any discrepancy between the available and required space in each dental arch quadrant.^[1] Management of a child's developing dentition usually requires this analysis to help predict space available to accommodate the erupting permanent canine and premolars.^[2] Mixed dentition analysis aids in following the most appropriate treatment plan for each case, whether the planned management would involve guidance of eruption, space maintenance, space regaining or regular follow-up without intervention. Inaccurate mixed dentition space analysis may lead to extraction of teeth, which could worsen the soft-tissue facial profile.^[3] There are several essential factors that facilitate the applicability of mixed dentition analysis, such as ease of use by

the dentist, minimum time required, a predictable methodical error, the requirement or otherwise of special instruments and whether it can be undertaken directly on both the maxillary and mandibular dentitions.^[4] Three procedures are most widely used for the prediction of the unerupted Σ CPP in each quadrant: Direct measurement of the mesiodistal (MD) width of the lower incisors (Σ I) from study models, allowing estimation of the Σ CPP using Moyers probability tables^[1] and Tanaka and Johnston's equations;^[5] calculation of tooth dimensions from radiographs, as suggested by Staley *et al.*;^[6,7] and a combination of both the radiographic and prediction table methods, as suggested by Hixon and Oldfather^[8] and by Bishara *et al.*^[9]

The first of these methods is the most widely used as no radiographs are required and the equations are applicable to

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both males and females for both maxillary and mandibular \sum CPP estimations. The precision of the technique is generally acceptable, although overestimation of the predicted widths has been reported by several authors.^[4,10,11] This might be due to the difference in ethnicity of the examined groups compared with the northern European descendants studied by Moyers^[1] and by Tanaka and Johnston.^[5] A meta-analysis^[12] concluded that Moyers prediction tables cannot be used for different populations and recommended the establishment of specific tables for each population.

Of the mixed dentition studies undertaken on different populations, relatively few have been conducted on Arabic subjects^[10,11,13,14] and, until to date, there is no published mixed dentition analysis for the Libyan population. Therefore, the aim of the current study was

- To assess the applicability of the Moyers' and Tanaka and Johnston correlation methods to Libyan subjects;
- To derive a correlation coefficient between the $\sum I$ and sum of the size of the maxillary and mandibular unerupted permanent canine and premolars (\sum UCPP and \sum LCPP respectively);
- To develop a prediction equation for Libyan subjects if required.

MATERIALS AND METHODS

This observational cross-sectional prospective study was granted ethical approval by the Faculty of Dentistry and the Ministry of Education in Benghazi-Libya.

Study Population

The targeted study group comprised Libyan schoolchildren attending intermediate schools in Benghazi city. The study sample was randomly selected from different schools located in five geographical regions: Central, Eastern, Western, Northern and Southern. Four schools were selected randomly from each area to ensure a representative population. At the time of the study, the number of students attending intermediate schools in the city was 43,881 which consist of 22,248 females and 21,633 males. The participants were required to be of Libyan origin for at least two previous generations (parents and grandparents) and to have no hypodontia or any craniofacial abnormalities. All the permanent teeth from the right first molar to the left first molar in each dental arch were required to be fully erupted, with no caries or restorations; no subjects had undergone previous orthodontic treatment. The sample group chosen was of an age where permanent dentition has almost erupted and the interarch occlusal relationship has been established; at this age, any need for orthodontic treatment is usually apparent. Relatively young subjects were chosen to minimize the influence of tooth wear, which might otherwise compromise the study outcome.

Clinical Examination

A list of children in each classroom was obtained and every fifth child was examined to assure randomization. A total of 900 students which consists of 453 males and 447 females; aged

range from 12 to 17 years) attending intermediate schools were examined at their school premises by one examiner (I.B). Only 343 subjects fulfilled the inclusion criteria (169 males with a mean age of 14.1 years, standard deviation (SD) =1.1 and 174 females with a mean age of 14.4 years, SD = 1.1). Parents of the students were informed and impressions were taken only from subjects whose parents agreed to participation in the study. Upper and lower alginate impressions and a wax bite registration were recorded and then casted on the same morning with dental plaster. All models were checked and numbered and a registration chart was prepared for each participant. The MD width of the lower permanent incisors, the upper and lower canines and the first and second premolars were recorded for each cast using an electronic digital caliper (BGS Germany Vernier Caliper 0-150; accuracy 0.01 mm) by one examiner (D.K). The caliper was positioned parallel to the vestibular surfaces and the occlusal plane. The same cohort was used to investigate the prevalence of malocclusion in Libyan schoolchildren.^[15]

Error of the Study

Intra-operator tooth measurement reproducibility was assessed by randomly checking thirty dental study models at 2-week intervals. A Paired *t*-test revealed no significant differences between both measurements at $P > 0.05$. The intra-class correlation coefficient was found to be greater than 0.90, indicating an excellent level of reproducibility between both trials.

Statistical Method

The data were entered into an Excel spread sheet (Microsoft Office 2007) and analyzed with the Statistical Package for Social Sciences version 17 (SPSS, Chicago, Illinois). The Shapiro-Wilk test was used to investigate the distribution of the data and Levene's test to explore the homogeneity of the variables. The data were found to be normally distributed and homogeneous. Quantitative data for the extracted MD tooth width was presented as mean, SD, standard errors of the estimate (SEE) and range. Student's Paired *t*-test and Pearson's product-moment coefficients were conducted to evaluate the possible asymmetry between the right and left groups of teeth. An independent Student's *t*-test was conducted to discriminate the sum of tooth groups between males and females. A Paired Student's *t*-test was used to compare the mean values of the measured and predicted MD widths of the buccal segments, according to Tanaka and Johnston's equations and Moyers' tables.

Linear regression equations ($y = a + bx$) were formulated to explore the relationship between $\sum I$ (x) and each of \sum UCPP and \sum LCPP, where y represents the estimated \sum CPP (dependent variable) and x characterizes the extracted $\sum I$ (independent variable). The terms a and b in the linear regression equation are constants, r^2 is the coefficient of determination, the value of which represents the power of regression models. Level of significance was set at $P < 0.05$.

RESULTS

Descriptive statistics (mean, SD and range) of $\sum I$, $\sum UCPP$ and $\sum LCPP$ were calculated for the whole sample and for males and female separately [Table 1]. An independent Student's *t*-test revealed a statistically significant sexual dimorphism between the means of summation of the $\sum I$ group ($P = 0.035$) with males showing larger teeth than females [Table 1].

The Tanaka and Johnston equations were applied to the current group to allow comparison between the definite and predicted maxillary and mandibular $\sum CPM$ for the pooled sample and for males and females. A Paired Student's *t*-test revealed significant discrepancies between the predicted and extracted measurements ($P < 0.001$) for all groups [Table 2].

There were significant discrepancies ($P \leq 0.036$) between the measured values of the maxillary and mandibular buccal segments and their predicted widths obtained from Moyers' tables at 35%, 50% and 75% probability levels for both males and females, except for the observed difference between the measured and predicted values at the 35% level for males at $P = 0.107$ [Table 3].

Table 4 shows the regression values for prediction of $\sum UCPP$ and $\sum LCPP$ separately (as the dependent variables) using $\sum I$ (the independent variable). The correlation coefficient values (*r*) were greater in males, at 0.66 for the maxillary and 0.68 for the mandibular buccal segments, than in females, at 0.57 for the maxillary and 0.58 for the mandibular buccal segments. The SEE ranged from 0.81 to 0.89 with similar errors in both males and females. Nearly 95% of the confidence interval values ranged between 0.62 and 0.33, with higher values in males than in females. Analysis of variance of linear regression of the respective equations of the current study produced *F*-values between 83.77 (1-172 degrees of freedom) and 230.68 (1-341 degrees of freedom), all demonstrating significant *P* values ($P < 0.001$). These results indicate that all the variances due to regression were highly significant and thus it is doubtful that the relationship between *x* and *y* in the regression equations are due to chance. The values of the coefficient *b* ranged from 0.41 to 0.53 when the regression equation was presented as $y = a + bx$ where *y* is the predicted $\sum UCPP$ and $\sum LCPP$, *x* equals the $\sum I$ and *a* and *b* are constants.

In this study, applying the values of coefficients *a* and *b* [Table 4] for the prediction of $\sum UCPP$ and $\sum LCPP$ gave the following:

For males: Maxilla $y = 9.63 + 0.53 (x)$

Mandible $y = 9.29 + 0.52 (x)$

For females: Maxilla $y = 11.71 + 0.43 (x)$

Mandible $y = 11.84 + 0.41 (x)$

For the MD parameters of the maxillary and mandibular buccal segments derived from the present data using regression equations, SD (ranging between 0.78 and 0.57) and SEE (ranging between 0.06 and 0.07) for both males and females were fairly low, suggesting a reduced discrepancy relative to the mean [Table 5]. No significant differences were observed between the means of the sums of the calculated MD widths of the buccal segments and the means of the sums of the predicted widths using the regression equation at $P \geq 0.093$ [Tables 5 and 6].

DISCUSSION

This cross-sectional study was undertaken on a random sample of Libyan schoolchildren, 12-17 years of age, living in Benghazi City. There have been a number of similar studies exploring mixed dentition analysis in schoolchildren.^[3,4,10,11,13,16,17] However, this is the first study on Libyan subjects to derive new regression equations and the study sample is one of the largest used for mixed dentition analysis. Moreover, the examined group was chosen to be young enough to avoid the potential complications of tooth wear that might otherwise compromise tooth measurement.

Tooth size and craniofacial features vary between different races and ethnicities^[4,8,12] resulting in limited usefulness of mixed dentition prediction equations for the examined population. Accordingly, a meta-analysis recommended the development of prediction tables specific to each population.^[12] A significant linear correlation between $\sum I$ and the maxillary and mandibular $\sum CPM$ has been recognized since 1949.^[18] Subsequently, a number of linear regression equations have been advocated for different populations.^[5,16,19,20]

In the present study, there were no significant differences between the Paired $\sum UCPP$ and $\sum LCPP$ measurements and as a result all statistical analyses were based on averaging the right and left Paired measurements. In males, the means and ranges of $\sum I$ were significantly greater than in females, while the SD in both sexes was comparable.^[2,4,10,13,17,20]

The $\sum UCPP$ in males was the only measure that was similar to the estimated value obtained from Moyers' tables at a probability level of 35%. This finding is comparable with the outcome of similar

Table 1: Descriptive statistics for the sum of the mesiodistal width of mandibular incisors ($\sum I$) and maxillary and mandibular buccal segment ($\sum UCPP$ and $\sum LCPP$) in mm

Tooth groups	Males (n = 169)			Females (n = 174)			P
	Mean (SD)	Range	SEE	Mean (SD)	Range	SEE	
$\sum I$	23.00 (1.46)	19.34-27.12	0.11	22.67 (1.40)	19.04-25.70	0.11	0.035
$\sum UCPP$	21.70 (1.17)	18.66-24.59	0.09	21.55 (1.06)	18.56-24.43	0.08	0.208
$\sum LCPP$	21.33 (1.13)	18.55-24.44	0.09	21.16 (0.99)	18.78-23.88	0.08	0.152

SD – Standard deviation; SEE – Standard errors of estimate; UCPP – Upper canine and first and second premolars; LCPP – Lower canine and first and second premolars

studies conducted on Saudi^[11] and Egyptian subjects.^[10] The significant linear correlation between $\sum I$ and $\sum UCPP$ and $\sum LCPP$ allowed the development of regression equations in the form of $y = a + bx$ for both the maxillary and mandibular arches.

The r^2 values indicate predictive precision of the equations for y ($\sum CPP$) derived from the value of x (the corresponding width of $\sum I$). This coefficient corresponds to the percentage of the total variance of y , which is determined by the x value of each regression equation. Moreover, $1-r^2$ reveals the proportion of error of variance of the prediction.^[21] It was noted that r^2 for the maxillary and mandibular teeth in males was 0.43 and 0.46, respectively. Hence, 43% and 46% of the total variances for both $\sum UCPP$ and $\sum LCPP$, respectively, can be deduced if $\sum I$ is known. Similarly, the r^2 for both the maxillary and mandibular teeth in females was 0.33 and 0.34, respectively. Jaroontham and Godfrey^[4] observed a higher r^2 value for females (0.39 for the maxillary and 0.42 for the mandibular teeth) compared to males (0.29 and 0.34, respectively). On the other hand, Hammad and Abdellatif^[10] noticed a higher r^2 for maxillary and mandibular buccal segment teeth in males (0.62 and 0.81, respectively) compared with females (0.40 and 0.77, respectively). The reported differences might be due to the different ethnicities of the examined groups and due to differences in sample size.

The SEE indicates errors involved in the use of prediction equations. As the value of SEE declines, usefulness of

the prediction equation improves. The SEE in the present study ranged from 0.81 to 0.89 mm and was higher for the maxillary teeth in both male and female groups (0.89-0.87 mm respectively), compared to the corresponding mandibular values: (0.83-0.81 mm respectively). For instance, nearly 68% of all potential male participants would have an estimated $\sum UCPP$ size accurate to within 1 SEE (0.89 mm) of their actual size. In 95% of all participants, the actual size of the $\sum UCPP$ would range between two SEEs above and below the value inferred from the regression equation. The SEE values in the current study (ranging between 0.81 mm and 0.89 mm) are similar to those reported for the Thai population^[4] (0.78 mm to 0.88 mm) and for Egyptian subjects^[10] (0.72-0.88 mm).

In the present study, the Tanaka and Johnston equations have been applied to allow comparison between the predicted size of $\sum UCPP$ and $\sum LCPP$ and known sizes that were extracted from measurements. Significant differences were revealed between both measurements. Furthermore, Tanaka and Johnston's^[5] regression equations overestimated the MD width of both the maxillary and mandibular buccal segments compared with the extracted measurements on the study models. These findings are similar to those reported previously for several ethnic backgrounds.^[10,11,13,17,22,23] This supports the conclusions of Buwembo and Luboga's^[12] meta-analysis that mixed dentition analyses cannot be universally applied. However, the literature currently lacks studies that examine the clinical significance of the errors of tooth size prediction.^[13]

Clinically, significant tooth size disparity has been investigated in a number of studies that examined Bolton discrepancies for different populations. A tooth size discrepancy of 2 mm was suggested by Othman and Harradine,^[24] while Proffit and Fields^[25] set the threshold of clinically significant tooth size discrepancy at 1.5 mm, judging anything less to be not significant. However, arrival at these values was not by evidence based methods. It will therefore be of interest to further explore the value of clinical significance in the prediction of tooth width in mixed dentition.

CONCLUSIONS

- Significant sexual discrepancy in tooth size was evident in the study group, with males having larger teeth than females;

Table 2: The difference between the mean values (mm) of actual sum of the MD widths of the maxillary and mandibular buccal segments obtained from the current study and Tanaka and Johnston equation

Groups	$\sum CPP$	Mean (SD)		Mean difference	95% CI
		Present study	Tanaka and Johnston		
Total sample	Maxilla	21.62 (1.12)	22.42 (0.72)	0.80	-0.89 (-0.70)
	Mandible	21.24 (1.06)	21.92 (0.72)	0.67	-0.76 (-0.59)
Male	Maxilla	21.70 (1.17)	22.50 (0.73)	0.80	-0.93 (-0.66)
	Mandible	21.33 (1.13)	22.00 (0.73)	0.67	-0.80 (-0.55)
Female	Maxilla	21.55 (1.06)	22.34 (0.70)	0.97	-0.92 (-0.66)
	Mandible	21.16 (0.99)	21.84 (0.70)	0.68	-0.79 (-0.55)

MD – Mesiodistal; SD – Standard deviation; CI – Confidence interval; CPP – canine and first and second premolars. All the differences were statistically significant ($P < 0.001$)

Table 3: The difference between the mean value (mm) of actual sum of width of the maxillary and mandibular buccal segments from the present study and those predicted from Moyers tables of the same sample at 35%, 50% and 75% probability levels

Arch	Percentile probability %	Males			Females		
		Mean difference (SD)	95% CI	P	Mean difference (SD)	95% CI	P
Maxilla	35	0.111 (0.88)	-0.02 (0.25)	0.107	0.14 (0.89)	0.01 (0.27)	0.036
	50	-0.235 (0.88)	-0.37 (-0.10)	0.001	-0.21 (0.89)	-0.34 (-0.08)	0.002
	75	-0.890 (0.88)	-1.02 (0.75)	<0.0001	-0.86 (0.86)	-0.99 (-0.73)	<0.0001
Mandible	35	0.228 (0.84)	0.10 (0.36)	0.001	0.26 (0.85)	0.13 (0.39)	<0.0001
	50	-0.472 (0.84)	0.60 (-0.35)	<0.0001	-0.44 (0.85)	-0.57 (-0.31)	<0.0001
	75	-0.872 (0.84)	0.99 (-0.75)	<0.0001	-0.84 (0.85)	-0.97 (-0.71)	<0.0001

CI – Confidence interval; SD – Standard deviation; MD – Mesiodistal

Table 4: Regression parameters for the prediction of the sum of the MD widths of the maxillary and mandibular buccal segments (CPP)

Sex	∑ CPP	r	Constant		SEE (mm)	r ²	95% CI
			a	b			
Male	Maxilla	0.66	9.63	0.53	0.89	0.43	0.43 (0.62)
	Mandible	0.68	9.29	0.52	0.83	0.46	0.44 (0.61)
Female	Maxilla	0.57	11.71	0.43	0.87	0.33	0.34 (0.53)
	Mandible	0.58	11.84	0.41	0.81	0.34	0.33 (0.50)

r – Correlation coefficient; r² – Coefficient of determination; CI – Confidence interval; SEE – Standard errors of estimate; MD – Mesiodistal; CPP – Canine and first and second premolars

Table 5: Descriptive statistics for the prediction of the maxillary and mandibular widths of the canine and premolars (mm) using regression equations obtained from the present study at P ≥ 0.093

Sex	∑ CPP	Paired samples test		
		Mean (SD)	SEE	Range
Males	Maxilla	21.82 (0.78)	0.07	19.88-24.00
	Mandible	21.25 (0.76)	0.06	19.35-23.39
Females	Maxilla	21.46 (0.60)	0.07	19.90-22.76
	Mandible	21.14 (0.57)	0.06	19.65-22.38

SEE – Standard errors of estimate; SD – Standard deviation; CPP – Canine and first and second premolars

Table 6: The differences between the predicted MD widths of the buccal segments (∑ CPP) and their actual measured dimensions (mm) of Libyan children from Benghazi

Sex	∑ CPP	Mean difference (SD)	95% CI
Males	Maxilla	-0.09 (0.40)	0.01 (0.25)
	Mandible	0.08 (0.33)	0.05-0.020
Females	Maxilla	0.09 (0.30)	0.04-0.022
	Mandible	0.03 (0.27)	0.01-0.010

SD – Standard deviation; CI – Confidence interval; MD – Mesiodistal; CPP – Canine and first and second premolars

- Both the Moyers and Tanaka and Johnston correlation methods are not accurate when estimating the size of canines and premolars in Libyan subjects;
- The prediction equations developed will assist in treatment planning in Libyan children.

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