Original Article

Mixed Dentition Analysis in a Jordanian Population

Zaid Bakri Al-Bitar[a]; Iyad Khaled Al-Omari[b]; Hawazen Nezar Sonbol[c]; Hazem Tayseer Al-Ahmad[d]; Ahmad Mohammad Hamdan[e]

ABSTRACT

Objective: To examine the applicability of the Tanaka and Johnston method of prediction in a Jordanian population and to develop a new prediction method for this specific population if necessary.

Materials and Methods: Three-hundred and sixty-seven Jordanians (193 female, 174 male, mean age 15.5 years) were randomly selected to represent 0.1% of 10th grade schoolchildren from Amman, Jordan. The mesiodistal crown diameters of the permanent teeth were measured and compared with the predicted values derived from the Tanaka and Johnston equations.

Results: Significant sexual dimorphism was found in tooth sizes. The correlation coefficients between the total mesiodistal width of the mandibular permanent incisors and that of the maxillary and mandibular canines and premolars were found to be 0.60 and 0.66, respectively. There were significant differences between the actual measurements and measurements derived from the Tanaka and Johnston equations. New linear regression equations were derived for both genders to allow tooth size prediction in Jordanians.

Conclusions: There is a limitation in the application of the Tanaka and Johnston's prediction method to a Jordanian population. It is important to use separate equations for male and female patients.

KEY WORDS: Mixed dentition analysis; Prediction equations; Probability tables

INTRODUCTION

Mixed dentition analysis is an important aspect of orthodontic diagnosis and treatment planning. It is a valuable tool in determining whether the treatment plan may involve serial extraction, guidance of eruption, space maintenance, space regaining, or just periodic observation of the patient.

Three basic approaches for prediction of the size of the unerupted permanent teeth during the mixed dentition have been used. Measurement of the size of the unerupted teeth on radiographs, as recommended by Staley et al[1] and de Paula et al[2]; estimation from proportionality tables, as reported by Moyers[3] and Tanaka and Johnston[4]; and a combination of the radiographic and prediction table method, as recommended by Hixon and Oldfather[5] and Bishara et al.[6]

Mixed dentition analysis using Moyers tables and Tanaka and Johnston have several advantages. No radiographs are required, tables can be used for both the maxillary and mandibular arch estimations, and there is a fairly good accuracy despite a tendency to overestimate the size of unerupted teeth.[7] The development of these two methods, however, was based on data derived from a population of Northern European descent. Therefore, the accuracy of these prediction methods may be in question when applied to a population of different ethnic origin.

A review of the literature revealed that mixed dentition analyses were varied between different racial and population groups: Ferguson et al[8] and Frankel and Benz[9] for black Americans; Schirmer and Wiltshire[10] for black Africans; Lee-Chan et al[11] for Asian-Americans; Bishara et al[6] for population samples from Egypt, Mexico, and the USA; Flores-Mir et al[12] for Peruvians; Al-Khadra[13] for Saudi Arabians; Nourallah et

[a] Assistant Professor, Departments of Orthodontics and Pediatric Dentistry, University of Jordan, Amman, Jordan.

[b] Assistant Professor, Orthodontic Department, University of Jordan, Amman, Jordan

[c] Assistant Professor, Departments of Orthodontics and Pediatric Dentistry, University of Jordan, Amman, Jordan.

[d] Assistant Professor, Oral and Maxillofacial Surgery Department, University of Jordan, Amman, Jordan.

[e] Associate Professor, Departments of Orthodontics and Pediatric Dentistry, University of Jordan, Amman, Jordan.

Corresponding author: Dr Zaid Bakri Al-Bitar, Department of Orthodontics and Pediatric Dentistry, University of Jordan, PO Box 13850, Amman, 11942, Jordan (e-mail: z.bitar@ju.edu.jo)

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al[14] for Syrians; Yuen et al[15] for Hong Kong Chinese; Jaroontham and Godfrey[16] for Thai population; Legovic et al[17] for Croatians; Otuyemi and Noar[18] for Nigerian; and Diagne et al[19] for Senegalese population. Populations of different racial origins generally had average values that were significantly different from those reported for whites, but in most cases the clinical significance was questionable.[20]

Several recent studies investigating mixed dentition analyses in different populations derived their samples from subjects attending orthodontic clinics; this may have introduced a source of bias because they may not be representative of the total population.[10,11,13,14,17] In addition, there was a wide variation in the sample sizes within these studies ranging from 34 to 600 subjects.

There have also been questions about applying these methods, which are based on pooled male and female data, rather than considering the sexes separately. In addition, there is some evidence of secular trends of changing dimension of teeth, which may require progressive modification of mixed dentition analysis for different populations.[20]

There are few published data on mixed dentition analysis for Arabic populations.[13,14] The purposes of this study were to: (1) examine the applicability of the Tanaka and Johnston method of prediction in a Jordanian population; and (2) develop a new prediction method for this specific population if it proved to be necessary.

MATERIALS AND METHODS

Sample Selection

The sample comprised 1439 Jordanian adolescents (mean age: 15.5 years, SD = 1.2 years) attending the 10th grade of 12 schools representing the six regional directories of the capital of Jordan, Amman. The schools were randomly selected from a list of all the schools in Amman obtained from the Ministry of Education in Jordan. A sample representative of 0.1% of the population was drawn for each directory. Ethical approval for the study was obtained from the Ministry of Health in Jordan and the Deanship of Academic Research at the University of Jordan. Written consent was obtained from the parents of all subjects who underwent examination and impressions.

Examinations were carried out by two examiners on the school premises under natural lighting. Alginate impressions were taken for subjects who fulfilled the following criteria:

- Jordanian ancestors at least from one previous generation,
- All permanent teeth erupted (except third molars),
- No interproximal caries or restorations,
- No missing or supernumerary teeth,
- No abnormally sized or shaped teeth,
- Minimal or no tooth wear,
- No previous orthodontic treatment.

Impressions were poured on the same day with hard dental stone, using standard procedures for the mixing, impression disinfection, and storage of impressions until they were poured. The dental casts were not soaped or waxed.

Of the total sample examined, 395 subjects (27.4%) fulfilled the inclusion criteria and were included in the study. A further 28 dental casts (1.9%) were excluded because they were of inadequate quality. The final number of study models used in the present study therefore was 367 (25.5%), of which 193 were female and 174 were male subjects.

Power calculations indicated that a difference of one standard deviation would be detected with a power of 0.89 ($\alpha = 0.05$) for the present sample size of 367.[21]

Methods

The measurements were carried out using a digital caliper (Orteam, Lotto 56, Milano, Italy) with an accuracy of 0.01 mm. The mesiodistal widths of teeth were taken by the two examiners according to the method described by Hunter and Priest.[22]

Method Error

Prior to the study proper, intraexaminer and interexaminer errors were assessed by randomly selecting the study models of 20 subjects and having each observer measure them on two occasions at 2-week intervals. Systematic bias was examined using a paired *t*-test[23] and estimation of random error was carried out using the index of reliability by correlating repeat measurements.[24] Error analysis showed no significant intraexaminer and interexaminer differences when systemic bias was tested ($P > .05$). Intraexaminer and interexaminer correlations of repeat measurements were found to be greater than 0.95, indicating no random error.

Statistical Analyses

Statistical analysis was carried out using the SPSS statistical package (SPSS Release 12.0.1 for Windows 2003. SPSS Inc, Chicago, Ill). An independent sample *t*-test was used to measure differences between genders, and a paired sample *t*-test was used to compare between measurements of contralateral teeth. Linear regression was used to derive equations for the prediction of the sum of the widths of the maxillary canine, and first and second premolars, and the sum of the widths of the mandibular canine, and first and second premolars. The sum of the mandibular incisor widths

Table 1. Descriptive Statistics for Summations of Mesiodistal Widths of Mandibular Incisors, and Maxillary and Mandibular Canine and Premolar Segments[a]

	Males (n = 174)			Females (n = 193)				
	Mean mm	Range	SD	Mean mm	Range	SD	*t* Value	*P* Value
Σ Mandibular incisors	23.2	18.67–26.99	0.34	22.8	18.56–26.12	0.31	2.75	.006
Mandibular Canine and Premolars	21.6	18.65–24.82	0.07	20.7	17.73–24.01	0.42	8.01	.000
Maxillary Canine and Premolars	21.9	19.64–25.52	1.47	21.2	14.54–23.98	1.13	6.16	.000

[a] SD indicates standard deviation.

Table 2. Regression Parameters for Prediction of Summations of Mesiodistal Widths of the Canine and Two Premolars in One Quadrant[a]

	Σ 3 4 5 Segment	Correlation Coefficient (*r*)	Constants, mm		SEE, mm	Coefficient of Determination (r^2)	95% CI
			a	*b*			
Total sample	Maxilla	0.60	10.94	0.46	0.84	0.36	0.40–0.52
	Mandible	0.66	8.43	0.55	0.86	0.44	0.49–0.62
Male	Maxilla	0.57	11.80	0.43	0.88	0.33	0.34–0.53
	Mandible	0.65	9.32	0.53	0.87	0.42	0.44–0.62
Female	Maxilla	0.61	11.25	0.44	0.75	0.38	0.36–0.52
	Mandible	0.68	9.22	0.50	0.72	0.47	0.43–0.58

[a] SEE indicates standard error of estimates; CI, confidence interval.

Table 3. Descriptive Statistics for the Prediction of Mesiodistal Widths of the Canine and Two Premolars Using Regression Equations Derived From the Present Study[a]

	Σ 3 4 5 Segment	Mean	SD	SE	95% CI
Total Sample	Maxilla	21.5	0.64	0.046	21.37–21.55
	Mandible	21.1	0.76	0.055	20.91–21.13
Male	Maxilla	21.9	0.61	0.046	21.77–21.95
	Mandible	21.6	0.74	0.056	21.48–21.70
Female	Maxilla	21.3	0.59	0.044	21.20–21.37
	Mandible	20.6	0.66	0.050	20.53–20.72

[a] SD indicates standard deviation; SE, Standard Error; CI, confidence interval.

represented the independent variable, while mandibular and maxillary canines, and first and second premolar widths represented dependent variables. R-squared values (coefficient of determination) represented the power of the regression models. Significance was set at the 5% level ($P < .05$).

The regression equation was expressed as $Y = a + bx$, where Y represented the predicted combined mesiodistal widths of canines, and first and second premolars (dependent variable), and x represented the measured mesiodistal widths of the mandibular incisors (independent variable). Values a and b were constants and SEE was the standard error of the estimate.

RESULTS

Table 1 shows the descriptive statistics for the sums of the mesiodistal widths of the four mandibular incisors and the average of the right and left maxillary and mandibular canine and premolar segments divided according to gender. A gender discrepancy was seen in this study with boys showing significantly greater size of mandibular incisors and maxillary and mandibular canine and premolar segments. Statistical analysis of measurements at an individual tooth level revealed that there were significant differences between genders for all teeth measured ($P < .05$) except for the mandibular right central incisor and the maxillary right and left second premolars. There were no significant differences between measurements of contralateral teeth ($P < .05$) except for the maxillary and mandibular second premolars.

Table 2 shows the regression parameters for prediction of summations of mesiodistal widths of the canine and premolars (dependent variable) using the mesiodistal widths of the mandibular incisors (independent variable). The correlation coefficients ranged from 0.57 to 0.68 with coefficients higher in female subjects. The r^2 values ranged from 33% to 47% with the power of the regression model greater in female subjects.

Table 3 shows the descriptive statistics for the prediction of mesiodistal widths of the canine and two premolars using regression equations derived from the present study. Standard deviation and standard errors were relatively low indicating a reduced variance about the mean for the predictions.

The equations of Tanaka and Johnston[4] were applied to the present sample to allow comparison between the predicted mesiodistal widths of maxillary

Table 4. A Comparison Between Predicted Mesiodistal Widths of the Canine and Two Premolars Using Regression Equations From the Present Study and Tanaka and Johnston's Equations

	Σ 3 4 5 Segment	Present Study		Tanaka and Johnston		Difference	
		Mean mm	SD	Mean mm	SD	Mean mm	95% CI
Total sample	Maxilla	21.5	0.64	22.5	0.69	−1.0*	0.95–0.96
	Mandible	21.1	0.76	22.0	0.69	−0.9*	0.87–0.88
Male	Maxilla	21.9	0.61	22.6	0.70	−0.7*	0.72–0.75
	Mandible	21.6	0.74	22.1	0.70	−0.5*	0.51–0.52
Female	Maxilla	21.3	0.59	22.4	0.67	−1.1*	1.10–1.12
	Mandible	20.6	0.66	21.9	0.67	−1.3	**

[a] SD indicates standard deviation; CI, confidence interval.
* Significant at $P = .000$.
** CI could not be computed because the standard error of the difference is 0 (S.D. for both variables were equal).

and mandibular buccal segments and the actual measured widths. Statistical comparisons using *t*-tests showed significant differences between predicted and measured widths of maxillary and mandibular buccal segments for boys and girls and the pooled total sample ($P < .05$). Figure 1 illustrates an example of the highly significant differences between the predicted mesiodistal widths of the mandibular buccal segments using Tanaka and Johnston's equation and actual measured widths.

Table 4 shows the difference between mesiodistal widths predicted using regression equations derived from the present study and those derived by Tanaka and Johnston. Mean differences ranged from 0.5 to 1.3 mm. A paired sample *t*-test showed significant differences between the two prediction methods for boys, girls, and the pooled total sample ($P < .05$)

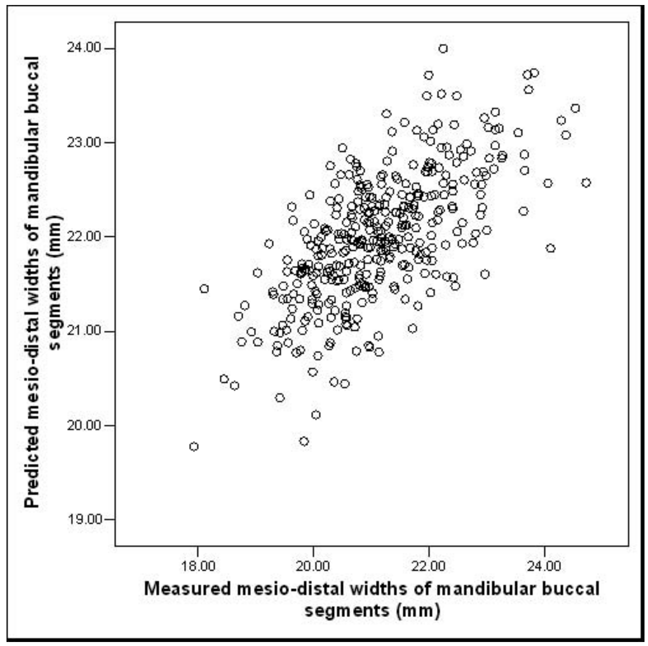

Figure 1. Predicted mesiodistal widths of mandibular buccal segments using Tanaka and Johnston's equation versus actual measurements.

DISCUSSION

There have been a few studies investigating a mixed dentition analysis in school-aged children.[12,15,16] The age of the sample was relatively young in order to eliminate and minimize the influence of tooth wear and loss. The study sample in this investigation was a random selection of 367 Jordanian 10th grade school children. The sample represents 0.1% of the 10th grade subjects in the Amman governance. The sample size in the present study is one of the largest assessing mixed dentition analyses (Table 5). This was evident from the power calculation performed.

A gender discrepancy was seen in this study, with boys showing significantly greater size of mandibular incisors, maxillary and mandibular canines, and premolar segments. This sexual dimorphism has been seen in other studies.[15–17,19] Division of subjects according to sex when performing mixed dentition analysis was therefore necessary.

Table 5 shows mesiodistal crown dimensions for male and female subjects published by various authors. The combined mesiodistal diameters of the canine-premolar segments and the mandibular incisors were relatively smaller than those of black South Africans,[10] but comparable to those of black Americans,[8,9] Hong Kong Chinese,[15] Thai,[16] and Senegalese groups.[19]

Findings from the present study showed that Tanaka and Johnston's method of prediction overestimates the mesiodistal widths of both maxillary and mandibular buccal segments compared with actual measurement on study casts ($P < .05$). This finding was similar to that of Asian Americans,[11] Senegalese,[19] black South Africans,[10] and Saudi Arabians.[13] Buwembo and Luboga[25] conducted a meta-analysis on the applicability of Moyer's method in different ethnic groups and concluded that it cannot be universally

Table 5. Summation of Mesiodistal Widths of Mandibular Incisors and Maxillary and Mandibular Canine Premolar Segments from Various Studies[a]

Study	Sample	Sex	Tooth Segment	Mean mm	SD
Schirmer & Wiltshire[10] (black South Africans)			Σ Mand. incisors	23.92	1.90
	50	M	Σ Mand. 3 4 5	23.22	1.11
			Σ Max. 3 4 5	23.45	1.37
			Σ Mand. incisors	23.66	1.59
	50	F	Σ Mand. 3 4 5	22.28	1.28
			Σ Max. 3 4 5	22.20	1.24
Frankel & Benz[9] (black Americans)			Σ Mand. incisors	23.06	1.59
	39	M	Σ Mand. 3 4 5	22.53	1.30
			Σ Max. 3 4 5	22.57	1.45
			Σ Mand. incisors	22.94	1.28
	41	F	Σ Mand. 3 4 5	21.78	0.83
			Σ Max. 3 4 5	21.58	0.94
Yuen et al[15] (Hong Kong Chinese)			Σ Mand. incisors	23.15	1.25
	51	M	Σ Mand. 3 4 5	23.37	1.10
			Σ Max. 3 4 5	22.30	0.39
			Σ Mand. incisors	23.28	1.22
	45	F	Σ Mand. 3 4 5	22.67	1.09
			Σ Max. 3 4 5	21.58	1.16
Jaroontham & Godfrey[16] (Thai)			Σ Mand. incisors	23.89	1.37
	215	M	Σ Mand. 3 4 5	23.16	1.04
			Σ Max. 3 4 5	23.31	1.03
			Σ Mand. incisors	23.23	1.26
	215	F	Σ Mand. 3 4 5	22.64	1.00
			Σ Max. 3 4 5	21.77	1.02
Diagne et al[19] (Senegalese)			Σ Mand. incisors	23.71	1.25
	25	M	Σ Mand. 3 4 5	22.70	1.01
			Σ Max. 3 4 5	22.60	1.22
			Σ Mand. incisors	22.86	1.12
	25	F	Σ Mand. 3 4 5	21.87	0.77
			Σ Max. 3 4 5	21.64	0.99
Present study			Σ Mand. incisors	23.20	0.34
	174	M	Σ Mand. 3 4 5	21.60	0.07
			Σ Max. 3 4 5	21.90	1.47
			Σ Mand. incisors	22.80	0.31
	193	F	Σ Mand. 3 4 5	20.70	0.42
			Σ Mand. 3 4 5	21.20	1.13

[a] SD indicates standard deviation.
Mand. 3 4 5 indicates Mandibular Canine and Premolars
Max. 3 4 5 indicates Maxillary Canine and Premolars

applied to different populations and it is safer to develop prediction tables for specific populations.

There have been no studies in the literature that attempted to investigate the error of tooth size prediction and its clinical significance. The threshold for clinical significance, however, was investigated by few studies when estimating the Bolton discrepancy.[26–28] Othman and Harradine[28] recommended a threshold of 2 mm in expressing a tooth size discrepancy. Bernabè et al,[27] however, chose 1.5 mm as a threshold based on Proffit[7] who stated that tooth size discrepancies less than this amount are rarely significant. But there was no mention of any investigation to support this. The amount of the threshold for clinical significance in the prediction of tooth size in the mixed dentition needs further investigations.

CONCLUSIONS

- There are limitations in the application of Tanaka and Johnston's prediction method to a Jordanian population.
- A gender discrepancy was seen in the present study with male subjects having significantly wider mandibular incisors and maxillary and mandibular canine and premolar segments.
- Jordanian subjects should be divided according to gender prior to carrying out a mixed dentition analysis and the corresponding equation applied.

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