Original Research Article

TANAKA AND JOHNSTON'S MIXED DENTITION VALIDITY: AN ANALYSIS AMONG YEMENI ADULTS IN SANA'A CITY

ABSTRACT

Introduction and objective: Mixed dentition space analysis methods via Tanaka-Johnston analysis are regularly used all over the world. Conversely, the applicability of this analysis between different ethnic groups is dubious. The study aimed to assess the applicability of the Tanaka-Johnston analysis among Yemeni adults and to develop regression equations for the same population if necessary. **Methods:** Two hundred and twenty-seven (106 males and 121 females) study models were recruited from Yemenis from Sana'a University, University of Science and Technology, and Al-Rehab's private clinic. The mesiodistal widths of the four permanent lower incisors, canines and premolars for all quadrants were measured with a digital caliper to the nearest 0.01 mm. Student's paired t-test was used to compare average presentation values derived from this study with values derived using Tanaka-Johnston equations, a chi-square ($\chi 2$) test used for appropriateness of fit. **Result:** Gender differences were observed in the total mesiodistal width of both canines and premolars in both arches as indicated by the t-test ($p < 0.001$). The sum of the actual mesiodistal width of the canines and premolars was compared with the expected widths derived from the Tanaka and Johnston equation and significant differences ($p < 0.001$) were found. Regression analysis indicated that the sum of the mesiodistal width of the permanent mandibular incisors is a good predictor of that of un-erupted canines and premolars, with correlation coefficients ranging from 0.51 to 0.61. Accordingly, two linear regression equations were developed to predict tooth width for Yemeni males and females. **Conclusion:** The Tanaka-Johnston analysis did not accurately predict the mesiodistal width of un-erupted canines and premolars for the Yemeni population. Moreover new regression equations were developed for the research sample. However, further studies should be conducted to confirm the applicability and accuracy of these equations.

KEYWORDS: adults, mixed dentition, regression equations, Tanaka-Johnston analysis, Yemen

INTRODUCTION

Accurate prediction of the mesiodistal widths of interrupted permanent canines and premolars is a valuable diagnostic tool for assessing and managing tooth size/arch length discrepancies during mixed dentition. Determining the space required to accommodate interrupted permanent canines and premolars is helpful in treatment planning for serial extractions, space maintenance, space regaining, eruption guidance or just observation of the patient [1]. Previous references in dentistry attempt to predict the sizes of un-erupted teeth according to Black's average of the sizes of mesiodistal teeth. Clinically, these estimates were not reliable due to the large variation in tooth size between different persons. In an effort to obtain greater accuracy, several methods were consequently developed and used to predict the sizes of un-erupted teeth. Currently, there are three commonly used methods for predicting the un-erupted presentation of the permanent canine and the mesiodistal premolar, which are radiographic methods, non-radiographic methods, and a combination of both methods [2-4] . These three methods have been reported for estimating mesiodistal width of canines and premolars that have not been erupted: 1) Measurements of theun-erupted dentition on radiographs[5]. 2) Calculations from prediction equations and tables[6-8] 3) a mixture of both[9]. Tanaka and Johnston developed linear regression equations to predict the mesiodistal width of unerupted canines and premolars among European ancestors [7]. This prediction method has gained prevalent clinical reception for the reason that it is uncomplicated, accommodating, fairly accurate and non-invasive [10]. Numerous studies have explored the applicability of Tanaka and Johnston's prediction method to different populations. The outcomes of these studies discovered that Tanaka and Johnston's prediction method is not accurate when applied to those populations [3-5,11-19]. Furthermore, gender differences in the sum of canine mesiodistal width and premolars have been reported in the literature [2-4,20-22].

Although there are different studies on oral and dental problems in Yemen [24-37]. However, there is not even a single study to assess the applicability of the Tanaka-Johnston analysis among Yemeni adults and to develop regression equations for the population of Yemen. Because the applicability of this analysis between different ethnic groups is questionable. This study aimed to assess the applicability of

the Tanaka-Johnston analysis among Yemeni adults and to develop regression equations for the same population if necessary.

MATERIALS AND METHODS

The current study was conducted in the Faculty of Dentistry, University of Sana'a, Sana'a, Yemen from October 2020 to September 2021. The population in this study are adults in Sana'a city, as per the latest 2004 censuses for Sana'a city. The city, the population was 1,747,834 with an annual increase in growth rate of 2.8%. Accordingly, the total population in 2019 was about 2,644822, of which 38% were adults (1005032). If we suggest that only 34% had well-aligned lower incisors (Handbook of Orthodontics 2nd Edition). Confidence level equal to 90%, desired estimation accuracy equal to 5.2%; the sample size should not be less than 224 patients. Therefore, 227 pairs of study models were selected from the orthodontic records of patients (106 males and 121 females) seeking orthodontic treatment in different dental clinics, and the study was reviewed and approved by the Research Committee of the Faculty of Dentistry at Sana'a University. The selected sample fulfilled the following criteria: 1) Yemeni patients. 2) Age group: 19-25 years old; 3) the quality of the study models (smooth and free of bubbles, voids, breakage or any distortion); 4) no caries or restorations other than first-degree caries / restorations; 5) complete eruption of permanent teeth from the right first molar to the left first molar of the upper and lower jaw; 6) minimal crowding and absence of highly rotated teeth; 7) No deformed teeth. 8) No tooth erosion. 9) No previous orthodontic treatment.

An operator made measurements directly on the study models using an electronic digital caliper (Mitutoyo Manufacturing Co., Ltd., Tokyo, Japan) with 0.01 mm precision. The nibs of the calipers were inserted parallel to the occlusal surface, and then the distance between the contact points on the proximal surfaces was measured [38]. The mesiodistal width of the mandibular permanent incisors, maxillary, and mandibular permanent canines, and maxillary and mandibular permanent premolars were recorded. To make certain the dependability of the measurement, [39] couple of study models were at random selected as well as re-measure by the same examiner at an interval of one week and compare with the first measurements. The double-sample t-test indicated that there was no statistically significant difference between the first and second readings ($p > 0.1$ and standard errors of 0.004). Pearson's correlation coefficient showed a high correlation between the first reading and the second reading (0.99 or more).

Statistical analysis was performed using the Statistical Package for the Social Sciences, version 16.0 (SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were considered for the sum of the actual width of the canines, premolars and mandibular incisors. Independent sample t-tests were considered to compare tooth width between the sexes. Two-sample t-tests were used to compare the difference between the expected values derived from the Tanaka and Johnston equation and the sum of the actual width of the canine and premolars. The regression equations for Tanaka and Johnston are: $Y = 10.5 + 0.5 (X)$ for the lower jaw teeth and $Y = 11.0 + 0.5 (X)$ for the upper teeth, where Y is the sum of the width of the mesiodistal width canines and premolars in one quadrant, and X is the sum of the mesiodistal width of the mandibular incisors . From the study data, new regression equations were formulated to predict tooth width in the Yemeni population and are expressed as $Y = A + B (X)$. The constants "a" and "b" for females and males were calculated separately.

RESULTS

Table 1 shows the frequency of data distribution according to sex. The study included 106 (46.7%) males and 121 (53.3%) females. A paired t-test was carried out to test for the difference in the sum of the the mesiodistal width of the right and Left canines and premolars in both arches. No statistical significance was found at the 0.05 level of significance. For that reason, the results of the left and right measurements were combined for statistical analysis. Table 2 shows the descriptive statistics of the sum of the mesiodistal widths for the mandibular incisors, maxillary canines and premolars, and mandibular canines and premolars among male and female individuals. Gender differences were observed in the sum of canine the mesiodistal width and premolars in both arcs as indicated by t-test ($p < 0.001$). Statistically significant differences ($P < 0.001$) were found between the sum of the actual mesiodistal widths for canines and premolars and the expected widths derived from the Tanaka and Johnston equation for male and female patients (Table 3). Tanaka and Johnston equation overestimated the sum of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients in the current study sample.

New regression equations for the mesiodistal width of maxillary and mandibular canines and premolars of males (Y), there was a significant linear relationship with the mesiodistal width of lower incisors (X), with respective correlation coefficient and coefficient of determination in maxilla (r=0.0.447; r^2=20%) and in mandible (r=0.439; r^2=21%). The simple linear regression equations Y=14.854+0.354X and Y=14.408+0.358X were the best fitting equations for predicting the maxillary and mandibular canine

and premolar width for males (Y) (Table 4). Similarly, the mesiodistal width of maxillary and mandibular canines and premolars of females can be predicted by the linear equations Y=15.133+0.322X and Y=12.56+0.414X (Table 3). These linear regression equations were the best fitting model with respective correlation coefficient and coefficient of determination in maxilla (r=0.385; r^2=14.8%) and in mandible (r=0.40; r^2=16).

DISCUSSION

The purpose of the study was to test the applicability of Tanaka and Johnston's predictions in Yemeni society and try to develop a new prediction formula for Yemenis if necessary. The age range of the subjects in this study was 19 to 25 years with mean = SD = 21.64 ± 1.6 years of age to minimize the effect of attrition, caries, or tooth loss on mesiodistal width of teeth[40]. An operator performed the measurements directly on the study models using an electronic digital caliper. Zilberman *et al.* [39] found that measurement with a digital caliper produces the most accurate and reproducible results. It has been reported in the literature that male teeth are generally larger than female teeth [18-21, 41].

In this study, gender variations were observed in the total of mesiodistal width of canine and premolars in both arches. Hence, data analysis was carried out singly for each gender. The results showed that the Tanaka and Johnston equation underestimated the total of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients in the current study sample. This contradicts the results of the study conducted on Saudis which reported an overestimation of the Tanaka and Johnston equation for the sum of the mesiodistal widths of mandibular and maxillary canines and premolars for male and female individuals [2, 23]. Among other populations, several studies have also reported either overestimating or underestimating the width of un-erupted canines and premolars when using Tanaka-Johnston prediction equations[1,2,14-19,42]. The regression analysis in this study designated that the sum of the mesiodistal width of the mandibular permanent incisors are a good indicator of those that have been not erupted canines and premolars. The correlation coefficients ranged from 0.385 to 0.447, which are somewhat slightly similar and comparable to those reported for the Jordanians [9], Iranians[17], and Thais[41], and less than those reported for Saudis [2,23]. The coefficient of determination (r2), indicators of how well the regression equations are predicted, ranged from 0.148 to 0.21 in this study. These were lower than those of Nepalese [18], Saudis [2,23] and Thais [41] but similar to those reported for Turks [19] and white Brazilians [43]. The standard error of the estimate ranged from 0.076 to 0.091 and indicates the reliability of the prediction equations proposed in this study. The results of the present study revealed that the Tanaka and Johnston equation does not apply to Yemenis. However, more work is needed on a large representative sample from different parts of Yemen to represent the population of Yemen and to reach a conclusive conclusion.

CONCLUSION

In conclusion, the Tanaka and Johnston prediction equation underestimated the sum of the mesiodistal widths of mandibular and maxillary canines and premolars for male and female individuals in the current study sample. The following prediction equations were derived for Yemenis: males (maxilla: Y=14.854+0.354X, mandible: Y=14.408+0.358X); and females (maxilla: Y=15.133+0.322X, mandible: Y=12.56+0.414X).

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CONFLICT OF INTEREST

No conflict of interest associated with this work.

AUTHOR'S CONTRIBUTIONS

All authors co-wrote the article and reviewed the results. Clinical parts and data analysis were performed by Waleed Abdelaziz Dahag and Hassan Abdelwahab Al Shamahy.

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Results

Table 1. Frequency of data distribution according to sex

Gender	Frequency	%
Male	106	46.7
Female	121	53.3
Total	227	100.0

Table 2 - Descriptive statistics and gender differences for the sum of mesiodistal widths of the mandibular incisors and maxillary and mandibular canine and premolars among Yemeni patients.

Variable	Male			Female			Independent t-test		
	n	Mean	SD	n	Mean	SD	t-test	df	P
Σ Mand. incisors	106	24.61	1.5	121	24.14	1.5	2.351	0.47	0.2
Σ Max. CPM	106	23.52	1.18	121	22.91	1.26	4.1	0.66	<0.001
Σ Mand. CPM	106	23.22	1.26	121	22.56	1.56	3.584	0.66	<0.001

Σ Mand. incisors - the sum of mesiodistal width of the mandibular incisors, Σ Max. CPM - the sum of mesiodistal width of the maxillary canine and premolars, Σ Mand. CPM - the sum of mesiodistal width of the mandibular canine and premolars, SD - standard deviation, df - degrees of freedom.

Table 3 - Comparison of the sum of the actual mesiodistal widths of canines and premolars and the predicted mesiodistal widths derived from the Tanaka and Johnston equation among Yemeni patients

Variable	Gender	Actual width		Predicted width (Tanaka-Johnston analysis)		Difference	SE	P value
		Mean	SD	Mean	SD			
Σ Max. CPM	Male	23.22	0.55	23.18	0.76	0.04	0.076	0.59
	Female	22.9	1.26	22.6	0.78	0.3	0.84	<0.001
Σ Mand. CPM	Male	23.2	1.17	22.22	0.77	0.98	0.087	<0.001
	Female	22.56	1.56	21.28	0.85	1.2	0.09	<0.001

Σ Max. CPM - the sum of mesiodistal width of the maxillary canine and premolars, Σ Mand. CPM - the sum of mesiodistal width of the mandibular canine and premolars, SD - standard deviation

Table 4 - Regression parameters for the prediction of the mesiodistal widths of maxillary and mandibular canine and premolars in the present study among Saudi patients.

Variable	**Gender**	**a**	**b**	**SEE**	**r**	**r^2**	**P***	**Regression equation**
Σ Max. CPM	Male	14.854	0.354	0.076	0.447	0.2	<0.001	Y=14.854+0.354X
	Female	15.133	0.322	0.084	0.385	0.148	<0.001	Y=15.133+0.322X
Σ Mand. CPM	Male	14.408	0.358	0.087	0.459	0.21	<0.001	Y=14.408+0.358X
	Female	12.56	0.414	0.091	0.400	0.16	<0.001	Y=12.56+0.414X

Σ Max. CPM - the sum of mesiodistal width of the maxillary canine and premolars, Σ Mand. CPM - the sum of mesiodistal width of the mandibular canine and premolars, SD - standard deviation, a & b - constants, r - correlation coefficient, r2 - coefficient of determination, SEE - standard error of estimate

*This procedure calculates the difference between the observed means in two independent samples. A significance value (P-value) and 95% Confidence Interval (CI) of the difference is reported. The P-value is the probability of obtaining the observed difference between the samples if the null hypothesis were true. The null hypothesis is the hypothesis that the difference is 0.