Available online on 15.01.2022 at *http://ujpr.org*
Universal Journal of Pharmaceutical Research
An International Peer Reviewed Journal
Open access to Pharmaceutical research

Volume 6, Issue 6, 2021

RESEARCH ARTICLE

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

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ABSTRACT

Introduction and objective: Mixed dentition space analysis methods via Tanaka-Johnston analysis are regularly used all over the world. Conversely, the appropriate of this analysis between different ethnic groups is dubious. The study aimed to test the appropriate of the Tanaka-Johnston analysis for Yemeni adults and to arise regression equations designed for Yemen population if needed.

Methods: The study included two hundred and twenty-seven (106 males and 121 females) Yemenis from Sana'a University, University of Science and Technology, and Al-Rehab Private Clinic. The mesiodistal widths of the four permanent lower canines, incisors, and premolars for the entire quadrants were determined with a digital caliper to the nearest 0.01 mm. To compare average presentation values derived from this study with values derived using Tanaka-Johnston equations, Student's paired t-test was used, as well as the 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 revealed 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: It was concluded from this study that the Tanaka-Johnston analysis did not accurately predict the mesiodistal width of the unruptured canines and premolars of the Yemeni population. Moreover, new regression equations have been developed for the research sample that can be a standard for Yemen. However, further studies must be performed to verify the applicability and accuracy of these equations.

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

Article Info: Received 10 November 2021; Revised 12 December; Accepted 29 December, Available online 15 January 2022

Cite this article-
Dahaq WAM, Al-Kholani AIM, Al-Kibsi TAM, Al-Deen HS, Al-Shamahy HA, AL-Haddad KA, Al-Akwa AAY, Al-labani MA. Tanaka and Johnston's mixed dentition validity: an analysis among Yemeni adults in Sana'a city. Universal Journal of Pharmaceutical Research 2021; 6(6):1-5.

DOI: *https://doi.org/10.22270/ujpr.v6i6.691*

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INTRODUCTION

A valuable diagnostic tool for evaluating and managing tooth size/arch length discrepancies during mixed dentition is the accurate prediction of the mesiodistal widths of interrupted permanent canines and premolars. In treatment planning, determining the space required to accommodate permanent interrupted canines and premolars is useful in planning treatment for serial extractions, space maintenance, space regaining, eruption guidance or just observation of the patient[1]. As this method depends on the average width of the lower incisors- the expected size of the permanent canines and premolars and the space available after the incisors are aligned correctly. But it neglects the criterion for changing between individuals according to

ethnic origin. 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 involving distinctive 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 techniques for calculating 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 radio-graphs[5]. 2). Calculations from prediction equations and tables)[6-8] 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 technique has gained prevalent clinical reception for the reason that it is uncomplicated, accommodating, fairly precise and non-invasive[10]. Numerous studies have explored the applicability of Tanaka and Johnston's prediction technique to different populations. The outcomes of these studies discovered that Tanaka and Johnston's prediction technique is not correct when used 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].

Even though there are different studies on oral and dental problems in Yemen[24-37]. However, there is not even a single study to test the applicability of the Tanaka-Johnston analysis for Yemeni adults and to work out regression equations for the population of Yemen. Because the applicability of this analysis between different ethnic groups is questionable. This study aimed to test the applicability of the Tanaka-Johnston analysis for Yemeni adults and to remodel regression equations for the same population if necessary.

METHODS

The current study was conducted in the Faculty of Dentistry, University of Sana'a, Sana'a, Yemen from October 2020 to September 2021which is the time that was determined by the college for the work of the master's thesis that undertook this research. The population in this study is adults in Sana'a city, as per the latest 2004 censuses for Sana'a city. The city, 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). It was suggested 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 sample selected for the study fulfilled the following criteria: 1). All individuals are Yemeni. 2). all in the age group: 19-25 years; 3). All the picks are of good quality as they are smooth and free from 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 first right molar to the left first molar of the upper and lower jaw; 6). All selectors have minimal crowding and the absence of highly rounded teeth; 7). No deformed teeth. 8). Does not erode the teeth. 9). No previous orthodontic treatment. Direct measurements were made on the selected subjects using an electronic digital caliper (Mitutoyo Manufacturing Co., Ltd., Tokyo, Japan) with an accuracy of 0.01 mm. Where the caliper nibs were inserted parallel to the occlusal surface, after which the distance between the points of contact on the proximal surfaces was measured[38].

Study models,[39] were randomly selected in addition to re-measurement by the same examiner in a period of one week and comparison with the first measurements in order to ensure the reliability of the measurement, and confirmed that the double-sample t-test indicated that there were no significant differences between the first and second readings (p>0.1 and standard errors of 0.004). In addition, the Pearson correlation coefficient showed a significant correlation between the first reading and the second reading (0.99 or more).

Statistical analysis

Using the Statistical Package for the Social Sciences, version 16.0 (SPSS Inc., Chicago, Illinois, USA) statistical analysis was performed. For the total actual width of the canines, premolars and lower incisors a descriptive statistic was considered. Independent sample t-tests were measured to compare tooth width between the sexes. From two samples to compare the difference between the expected values derived from the Tanaka and Johnston equation and the sum of the actual width of canine and premolars; t-tests were used. The regression equations for Tanaka and Johnston are: Y=10.5 + 0.5 (X) for the mandibular teeth and Y=11.0 + 0.5 (X) for the maxillary 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.

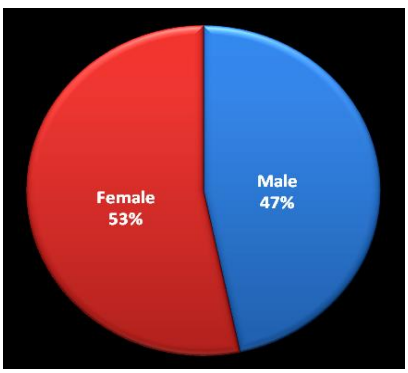

Figure 1: Gender distribution of participants.

RESULTS

Figure 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 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 1 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 2). 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 3). 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).

Table 1: 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.

DISCUSSION

The reason of the study was to investigation the applicability of Tanaka and Johnston's predictions in Yemeni society and try to work out 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]. In the current study 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 2). This result is similar to made by an operator performed the measurements directly on the study models with an electronic digital caliper; as did Zilberman *et al.*,[39]. These gender differences have also been reported in previous literature where male teeth are generally larger than female teeth[18-21,41]. In addition, 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.

Table 2: 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 3: Regression parameters for the prediction of the mesiodistal widths of maxillary and mandibular canine and premolars in the present study among Yemini 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, r^2 - coefficient of determination, SEE - standard error of estimate.

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]. In this study, regression analysis determined that the sum of the mesiodistal width of the mandibular permanent incisors is an excellent and appropriate indicator for those without erupting canines and premolars.

In the current study, 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 3). 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 (r^2), 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 assess 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

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

ACKNOWLEDGMENTS

The authors thank the Faculty of Dentistry, Sana'a University, Sana'a, Yemen for their generous support in providing working space and materials.

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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