

Is Tanaka-Johnston mixed dentition analysis an applicable method to a Saudi population?

Moshabab A. Asiry, BDS, MSc, Sahar F. Albarakati, BDS, MSc, Nassr S. Al-Maflehi, BSc (Statistics), MSc (Statistics), Alaa A. Sunqurah, BDS, Monirah I. Almohrij, BDS.

ABSTRACT

الأهداف: اختبار إمكانية استخدام طريقة تانكا وجونسون في المجتمع السعودي.

الطريقة: أجريت هذه الدراسة في الرياض - المملكة العربية السعودية من سبتمبر 2013م إلى يناير 2014م على 409 عينات من نماذج المعالجات التقويمية الجبسية، وقد تم قياس العرض الأنسي الوحشي للقواطع الدائمة السفلية والأنياب الدائمة والضواحك الدائمة باستخدام المقياس الرقمي الإلكتروني بمجال دقة 0.01 ملم، وقد تم مقارنة نتائج العرض الحقيقي مع النتائج المتوقعة من معادلة قياس تانكا وجونسون.

النتائج: لوحظ اختلاف النتائج بالعرض الأنسي الوحشي للأنياب والضواحك تبعاً لاختلاف الجنس في كلا الفكين وذلك باستخدام اختبار «ت» ذات الدلالة الاحصائية ($p < 0.001$). كما لوحظ الاختلاف بين العرض الحقيقي للأنياب والضواحك الدائمة مقارنة بالعرض المستنتج من معادلة تانكا وجونسون ($p < 0.001$). كذلك أشار تحليل الانحدار أن العرض الأنسي الوحشي للقواطع الدائمة السفلية كان متنبأ جيداً للأنياب والضواحك التي لم تبرز بعد وذلك بمجال توافق كافي من 0.51 إلى 0.61. وبناء عليه فإن معادلتنا التنبؤ الخطيتين لمعرفة العرض الحقيقي كانت مقبولتين للأشخاص السعوديين (نساء ورجال).

الخاتمة: لوحظ عند دراسة معادلة التقييم للعرض الأنسي الوحشي للأنياب والضواحك العلوية والسفلية باستخدام طريقة تانكا وجونسون بالإستفاضة في عينات الدراسة الحالية كما تم اعتماد معادلة قياس جديدة لعارض الأسنان في المجتمع السعودي.

Objectives: To test the applicability of the Tanaka and Johnston prediction method in a Saudi population.

Methods: The current study was conducted at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia from September 2013 to January 2014, on a sample of 409 pairs of orthodontic study models.

The mesiodistal width of the mandibular permanent incisors, permanent canines, and permanent premolars were measured using an electronic digital caliper with an accuracy of 0.01mm. The predicted widths derived from the Tanaka and Johnston equation were compared with the actual measured widths.

Results: Gender differences were observed in the sum of the mesiodistal width of canine and premolars in both arches as indicated by t-test ($p < 0.001$). The sum of the actual mesiodistal widths of canines and premolars were compared with the predicted widths derived from the Tanaka and Johnston equation and significant differences were found ($p < 0.001$). The regression analysis indicated that the sum of the mesiodistal width of the mandibular permanent incisors is a good predictor for those of unerupted canines and premolars, with the correlation coefficients ranging from 0.51 to 0.61. Accordingly, 2 linear regression equations were developed for tooth width prediction for Saudi males and females.

Conclusion: The Tanaka and Johnston prediction equation overestimated the sum of mesiodistal widths of permanent canines and premolars in Saudis. New regression equations were formulated for the prediction of tooth width in the Saudi population.

Saudi Med J 2014; Vol. 35 (9):

From the Department of Pediatric Dentistry and Orthodontics (Asiry, Albarakati), and the Department of Periodontics and Community Dentistry (Al-Maflehi), and the College of Dentistry (Sunqurah, Almohrij), King Saud University, Riyadh, Kingdom of Saudi Arabia.

Received 9th March 2014. Accepted 8th July 2014.

Address correspondence and reprint request to: Dr. Moshabab A. Asiry, Assistant Professor, Division of Orthodontics, Department of Pediatric Dentistry and Orthodontics, College of Dentistry, King Saud University, Building No 3500, Riyadh 12372-7051, Kingdom of Saudi Arabia. Fax: +966 (11) 4679017. E-mail: masiry@gmail.com

Accurate prediction of the mesiodistal widths of unerupted 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 unerupted 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

Three methods have been reported for estimation of the mesiodistal widths of unerupted canines and premolars: 1) measurements of unerupted teeth on radiographs;² 2) calculations from prediction equations and tables;³⁻⁵ 3) a combinations of both.⁶ Tanaka and Johnston developed linear regression equations for the prediction of the mesiodistal width of unerupted canines and premolars among European ancestry.⁴ This method of prediction has achieved widespread clinical acceptance because it is uncomplicated, flexible, relatively accurate and non-invasive.^{7,8} Several studies investigated the applicability of the Tanaka and Johnston prediction method on different population groups. The results of these studies revealed that the Tanaka and Johnston prediction method is not accurate when applied to those populations.^{1,8-13} Further, gender differences in the sum of the mesiodistal width of canine and premolars has been reported in literature.¹⁴⁻¹⁶

Al-Khadra¹⁷ investigated the reliability of the Tanaka and Johnston equations in Saudis. This study was based on a small sample size (34 patients) and pooled male and female data without considering the genders separately. Therefore, the aim of this study is to test the applicability of the Tanaka and Johnston prediction method in a Saudi population, and to attempt to develop a new prediction formula for Saudis, if necessary.

Methods. The current study was conducted at the College of Dentistry, King Saud University, Riyadh, Saudi Arabia from September 2013 to January 2014. Sample size calculation indicated that at $\alpha=0.05$ and $1-\beta=0.95$ with estimated standard deviation 1.2mm the sample size should be at least 360 patients. Therefore, 409 pairs of study models were selected from orthodontic records of patients (202 males and 207 females; average age of

15.10 \pm 0.45 years) seeking orthodontic treatment at different dental clinics. The study was reviewed and approved by the College of Dentistry Research Center (CDRC), King Saud University.

The selected sample fulfilled the following criteria: 1) Saudi patients; 2) age range: 13-20 years; 3) good quality of study models (smooth and free from bubbles, voids, fracture or any distortion); 4) no caries or resorption other than Class I caries/restorations; 5) complete eruption of permanent teeth from the right first molar to the left first molar of the maxillary and mandibular arch; 6) minimal crowding and absence of severely rotated tooth; 7) absence of malformed teeth; 8) absence of tooth wear; and 9) no previous orthodontic treatment.

One operator made the measurements directly on the study models using an electronic digital caliper (Mitutoyo Manufacturing Co. Ltd., Tokyo, Japan) with an accuracy of 0.01mm. The caliper beaks were inserted labially parallel to occlusal surface, then the distance between the contact points on proximal surfaces was measured.¹⁸ The mesiodistal width of the mandibular permanent incisors, maxillary, and mandibular permanent canines, and maxillary and mandibular permanent premolars were recorded.

To ensure the reliability of the measurement, 20 pairs of study models were randomly selected and re-measured by the same examiner with a one week interval and compared with the first measurements. The paired-sample t-test indicated that no statistical significant difference was observed between the first and the second readings ($p>0.1$ and standard errors ≤ 0.004). Pearson's correlation coefficient exhibited high correlation between the first and the second readings (0.99 or more).

Statistical analysis was conducted using the Statistical Package for Social Sciences, Version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were calculated for the sum of the actual width of canines and premolars and mandibular incisors. The independent sample t-tests were calculated to compare the tooth widths between genders. Paired-sample t-tests were used to compare the difference between the predicted values derived from the Tanaka and Johnston equation and the sum of the actual width of canine and premolars. Tanaka and Johnston regression equations are: $Y=10.5+0.5(X)$ for mandibular teeth and $Y=11.0+0.5(X)$ for maxillary teeth, where Y is the sum of the mesiodistal width of canine and premolars in one quadrant, and the X is the sum of the mesiodistal width of the mandibular incisors.

Disclosure. This study received funding from the College of Dentistry Research Center and Deanship of Scientific Research at King Saud University, Kingdom of Saudi Arabia (research project # FR 0063).

From the study data, new regression equations were formulated for the prediction of tooth width in the Saudi population and expressed as $Y=A+B(X)$. The constants 'A' and 'B' were calculated for female and male subjects separately.

Results. Paired t-test was executed to test the difference in the sum of the mesiodistal width of right and left canines and premolars in both arches. No statistical significance was found at a level of significance of 0.05. Therefore, the results of right and left measurements were combined for statistical analysis. Table 1 shows the descriptive statistics for the sum of the mesiodistal width of the mandibular incisors, maxillary canine and premolars, and mandibular canine and premolars

among male and female patients. Gender differences were observed in the sum of the mesiodistal width of canine and premolars in both arches as indicated by t-test ($p<0.001$).

Significant differences ($p<0.001$) were found between the sum of the actual mesiodistal widths of canines and premolars and the predicted 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 sample of the present study.

New regression equations. For the mesiodistal width of maxillary and mandibular canines and premolars of

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 Saudi patients.

Variable	n	Male		n	Female		Independent t-test		
		Mean	SD		Mean	SD	t-test	df	P-value
Σ Mand. incisors	202	21.45	1.34	207	21.57	1.70	-0.704	407	0.424
Σ Max. CPM	202	20.51	1.21	207	20.04	1.25	3.850	407	<0.001
Σ Mand. CPM	202	20.22	1.26	207	19.69	1.28	4.213	407	<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 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 Saudi patients.

Variable	Gender	Actual width		Predicted width		Difference	SD	P-value
		Mean	SD	Mean	SD			
Σ Max. CPM	Male	20.51	1.21	21.72	0.77	1.21	0.96	<0.001
	Female	20.04	1.25	21.78	0.85	1.74	1.08	<0.001
Σ Mand. CPM	Male	20.22	1.26	21.22	0.77	1.00	1.01	<0.001
	Female	19.69	1.29	21.28	0.85	1.59	1.23	<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 Saudi patients.

Variable	Gender	a	b	SEE	r	r ²	P-value	Regression equation
Σ Max. CPM	Male	10.3	0.49	0.96	0.61	0.37	0.002	$Y=10.3+0.49X$
	Female	11.7	0.37	1.07	0.52	0.27	0.002	$Y=11.7+0.37X$
Σ Mand. CPM	Male	9.7	0.49	1.01	0.60	0.36	0.002	$Y=9.7+0.49X$
	Female	11.3	0.39	1.11	0.51	0.27	0.002	$Y=11.3+0.39X$

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

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 ($r=0.61$; $r^2=37\%$) and in mandible ($r=0.60$; $r^2=36\%$). The simple linear regression equations $Y=10.3+0.49X$ and $Y=9.7+0.49X$ 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 $Y=11.7+0.37X$ and $Y=11.3+0.39X$ (Table 3). These linear regression equations were the best fitting model with respective correlation coefficient and coefficient of determination in maxilla ($r=0.52$; $r^2=27\%$) and in mandible ($r=0.51$; $r^2=27\%$).

Discussion. The purpose of the study was to test the applicability of the Tanaka and Johnston prediction method in a Saudi population and to attempt to develop a new prediction formula for Saudis if necessary. The age range of the subjects in the present study was between 13 to 20 years of age to minimize the effect of attrition, caries, or tooth loss on mesiodistal width of teeth.¹⁹ One operator made the measurements directly on the study models using an electronic digital caliper. Zilberman et al²⁰ found that measurement with digital calipers produced the most accurate and reproducible results.

It has been reported in the literatures that male teeth are generally larger than female teeth.^{12-15,21} In the present study, gender differences were observed in the sum of the mesiodistal width of canine and premolars in both arches. Therefore, the data analysis was performed separately for each gender. The results showed that the Tanaka and Johnston equation overestimated the sum of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients in the sample of the present study. This is in agreement with the results of previous study on Saudis reported by Al-Khadra.¹⁷ Among other populations, several studies also reported either overestimation or underestimation of the width of unerupted canines and premolars when using the Tanaka-Johnston prediction equations.^{1,8-13,22}

The regression analysis in this study indicated that the sum of the mesiodistal width of the mandibular permanent incisors is a good predictor for those of unerupted canines and premolars. The correlation coefficients ranged from 0.51 to 0.61, which is considered slightly high and comparable to those reported for the Jordanian,⁹ the Iranian,¹¹ and Thai population,²¹ and higher than those reported for the Nepalese.¹² The coefficient of determination (r^2), indicators of how well

the predictivity of the regression equations, ranged from 0.27 to 0.37 in this study. These were comparable to the Nepalese¹² and Thai population,²¹ but smaller than those reported for Turkish,¹³ and white Brazilians.²³ The standard error of estimate ranged from 0.96 to 1.11 and demonstrates the reliability of the prediction equations proposed in this study.

The results of the present study revealed that the Tanaka and Johnston equation is not applicable to Saudis. However, further work is needed on a large representative sample from different parts of the kingdom to represents the population of Saudi Arabia and to draw a firm conclusion.

In conclusion, the Tanaka and Johnston prediction equation overestimated the sum of mesiodistal widths of mandibular and maxillary canines and premolars for male and female patients in the sample of the present study. The following prediction equations were derived for Saudis: males (maxilla: $Y=10.3+0.49X$, mandible: $Y=9.7+0.49X$); and females (maxilla: $Y=11.7+0.37X$, mandible: $Y=11.3+0.39X$).

References

1. Oakley C, Brunette DM. The use of diagnostic data in clinical dental practice. *Dent Clin North Am* 2002; 46: 87-115.
2. Lysell L, Myrberg N. Mesiodistal tooth size in the deciduous and permanent dentitions. *Eur J Orthod* 1982; 4: 113-122.
3. Chandna A, Gupta A, Pradhan K, Gupta R. Prediction of the size of unerupted canines and premolars in a North Indian population: an in vitro study. *J Indian Dent Assoc* 2011; 5: 329-333.
4. Tanaka MM, Johnston LE. The prediction of the size of unerupted canines and premolars in a contemporary orthodontic population. *J Am Dent Assoc* 1974; 88: 798-801.
5. Boboc A, Dibbets J. Prediction of the mesiodistal width of unerupted permanent canines and premolars: a statistical approach. *Am J Orthod Dentofacial Orthop* 2010; 137: 503-507.
6. Cattaneo C, Butti AC, Bernini S, Biagi R, Salvato A. Comparative evaluation of the group of teeth with the best prediction value in the mixed dentition analysis. *Eur J Paediatr Dent* 2010; 11: 23-26.
7. Tome W, Ohyama Y, Yagi M, Takada K. Demonstration of a sex difference in the predictability of widths of unerupted permanent canines and premolars in a Japanese population. *Angle Orthod* 2011; 81: 938-944.
8. Nourallah AW, Gesch D, Khordaji MN, Splieth C. New regression equations for predicting the size of unerupted canines and premolars in a contemporary population. *Angle Orthod* 2002; 72: 216-221.
9. Abu Alhaija ES, Qudeimat MA. Mixed dentition space analysis in a Jordanian population: comparison of two methods. *Int J Paediatr Dent* 2006; 16: 104-110.
10. Bherwani AK, Fida M. Development of a prediction equation for the mixed dentition in a Pakistani sample. *Am J Orthod Dentofacial Orthop* 2011; 140: 626-632.

11. nik Tahere H, Majid S, Fateme M, Kharazi fard, Javad M. Predicting the size of unerupted canines and premolars of the maxillary and mandibular quadrants in an Iranian population. *J Clin Pediatr Dent* 2007; 32: 43-47.
12. Jaiswal AK, Paudel KR, Shrestha SL, Jaiswal S. Prediction of space available for unerupted permanent canine and premolars in a Nepalese population. *J Orthod* 2009; 36: 253-259.
13. Arslan SG, Dildeş N, Kama JD, Genç C. Mixed-dentition analysis in a Turkish population. *World J Orthod* 2009; 10: 135-140.
14. Mahmoud BK, Abu Asab SH, Taib H. Accuracy of four tooth size prediction methods on malay population. *ISRN Dent* 2012; 2012: 523703.
15. Flores-Mir C, Bernabe E, Camus C, Carhuayo MA, Major PW. Prediction of mesiodistal canine and premolar tooth width in a sample of Peruvian adolescents. *Orthod Craniofac Res* 2003; 6: 173-176.
16. Ling JY, Wong RW. Tanaka-Johnston mixed dentition analysis for southern Chinese in Hong Kong. *Angle Orthod* 2006; 76: 632-636.
17. Al-Khadra BH. Prediction of the size of unerupted canines and premolars in a Saudi Arab population. *Am J Orthod Dentofacial Orthop* 1993; 104: 369-372.
18. Hunter WS, Priest WR. Errors and discrepancies in measurement of tooth size. *J Dent Res* 1960; 39: 405-414.
19. Doris JM, Bernard BW, Kufinec MM, Stom D. A biometric study of tooth size and dental crowding. *Am J Orthod* 1981; 79: 326-336.
20. Zilberman O, Huggare JAV, Parikakis KA. Evaluation of the validity of tooth size and arch width measurements using conventional and three-dimensional virtual orthodontic models. *Angle Orthod* 2003; 73: 301-306.
21. Jaroontham J, Godfrey K. Mixed dentition space analysis in a Thai population. *The Eur J Orthod* 2000; 22: 127-134.
22. Burhan AS, Nawaya FR. Prediction of unerupted canines and premolars in a Syrian sample. *Prog Orthod* 2014; 15: 4.
23. Melgaco CA, Araujo MT, Ruellas AC. Applicability of three tooth size prediction methods for white Brazilians. *Angle Orthod* 2006; 76: 644-649.