ORIGINAL ARTICLE

Tanaka-Johnston's Mixed Dentition Analysis among Orthodontic Patients in Tanzania

Eladius Laswai Daniel, Ferdinand Mabula Machibya, Matilda Mtaya Mlangwa

Department of Orthodontics, School of Dentistry, Muhimbili University of Health and Allied Sciences (MUHAS)

ABSTRACT

Background: Lower incisors are the first teeth to erupt, their sizes are reliable and little changes occur on the lower arch during mixed dentition. These teeth can be used to predict the size of remaining unerupted teeth. Tanaka Johnston's analysis is the most widely used method of mixed dentition analysis worldwide. The aim of the study was to assess the accuracy of Tanaka-Johnston's methods of mixed dentition analysis among orthodontic patients in Tanzania.

Methods: A cross-sectional study design was carried out at MUHAS dental clinic involving models from orthodontic patients. Data collection involved actual teeth size measurement and prediction using Tanaka-Johnston's method. Comparison between the actual measurements and the predicted measurements was assessed using students' paired t-tests. Prediction equations for the present study were generated using a simple linear regression analysis.

Results: Tanaka Johnston's method significantly overestimated the combined width of upper canines and premolars in the female group (p=0.000). However, the method underestimated the lower jaw measurements in both sexes ($p<0.05$). New prediction equations for the present study were generated for each sex and arch separately. For the upper jaw, it was Y=11.97+ 0.56X for males and Y = 10.97+0.49X for females. While for the lower jaw, it was Y= 10.8 +0.51X for males and Y=11.39+0.47X for females.

Conclusion: Tanaka-Johnston's methods of mixed dentition analysis was found to be inaccurate in estimating the size of unerupted canines and premolars in the study sample. Therefore, new prediction formulas were generated.

INTRODUCTION

Mixed dentition analysis is the estimation of the mesial-distal teeth width of unerupted canines and premolars to determine the presence of any discrepancy between the available and required space [1]. There are three main methods of mixed dentition analysis. These methods are radiographic method, which is based on periapical and cephalometric radiographs, non-radiographic method which relies on teeth size correlation and the

Corresponding author:
Dr Ferdinand M. Machibya,
P. O. Box 65014, United Nations Road,
Upanga Magharibi
Muhimbili University of Health and Allied Sciences,
Dar es Salaam, Tanzania,
Email: frmachibya@yahoo.com; Mobile;+255 764982522.

Keywords: Dental aesthetic; Dental; Paediatric dentistry; Oral Health

This article is available online at: http://www.mjz.co.zm, http://ajol.info/index.php/mjz, doi: https://doi.org/10.55320/mjz.50.4.437

The Medical Journal of Zambia, ISSN 0047-651X, is published by the Zambia Medical Association

combination of both methods [2]. The most popular of these methods is non-radiographic.[3,4] Tanaka–Johnston's is the most commonly used method among the non-radiographic analyses [5]. However, the accuracy of this method has been questioned in several places in the world.[3,6] Furthermore, studies have shown that teeth sizes vary according to sex, ethnicity, race, origin and genetics of the studied population.[7–9] Therefore, the present study aimed to assess the accuracy of Tanaka–Johnson's method of mixed dentition analysis among orthodontic patients in the Tanzanian population.

Materials and Methods

The present study was a hospital-based cross-sectional study that involved 204 study models obtained conveniently from patients who sought orthodontic treatment at Muhimbili University Dental Clinic during the period of 2 years from February 2020 to August 2022.

Ethics Approval and Consent to Participate

The present study received the approval of the Institutional Ethical Committee of the Muhimbili University of Health and Allied Sciences (MUHAS-REC-07-2022-1282) and was carried out following the Helsinki Declaration on medical protocols and ethics. All the participants were well versed on the purpose of the study, before beginning of treatment written consent and assent (for children) were obtained from the parents/patient/guardian.

Inclusion criteria

The study included models of orthodontic patients aged between 12 and 30 years of age, all models were of good quality, well-taken and labeled properly. Also, these models had fully erupted permanent incisors, canines, premolars and first molars without any morphological anomalies.

Data collection process

A digital Vernier caliper with an accuracy of 0.01 mm (Guanglu, Guilin PR. China) was used to measure the mesio-distal width of all teeth anterior to the second molar. Mesio-distal width of each tooth was determined by measuring the maximum distance between contacting proximal surfaces. The caliper was positioned parallel to the vestibular surfaces and to the occlusal plane of the study model.[8,10] The predicted widths of canines and premolars were obtained by summing 11 mm to half of the sum of the lower four permanent incisors for the upper jaw while for the lower jaw, it was by adding 10.5 mm to half of the sum of the lower permanent incisors [11].

Validity

The digital Vernier caliper used in the present study was calibrated by a manual Vernier caliper where both calipers were used to measure the same models and they gave similar findings. A pilot study involving 20 study models was conducted before the present study and the investigator was calibrated on the use of a digital Vernier caliper with a senior calibrated Orthodontist.

Reliability

Data collection was carried out by only one examiner and to avoid random errors due to eye fatigue, only 5 study models were examined per day at an interval of one hour. In the middle of the data collection process, the examiner re-examined 15 study models taken randomly from the list of models that were already examined. The obtained second measurements were then compared with their previous measurements to assess intra-examiner reliability. Intra-class correlation coefficient (ICC) was calculated and found to be 0.98.

Data processing and analysis plan

Analysis was done using a computer Statistical Package for Social Sciences software (SPSS) version 25.0. An Independent sample t-test was used to assess whether the teeth size varies according to gender and arch type. The Mean, Standard Deviation (SD) and Standard Error of Estimate (SEE) of the actual teeth measurements were presented in

descriptive statistic distribution tables. Correlation analysis was done to assess the relationship between the sum of lower incisors and the combined mesio-distal width of the canines and the premolars. The relationship between the predicted measurements and the actual measurements was assessed using a paired sample t-test. The *p*-value $p<0.05$ was considered to be statistically significant. Simple linear regression equations were computed and expressed inform y = a + b(x) where; y is the combined mesio-distal widths of canines and premolars to be predicted, "a" is the Y Intercept "b" is the slope of the regression and x is the combined mesio-distal width of four lower incisors.

Ethical clearance to conduct the study was sought from the MUHAS Research Ethical Committee through the School of Dentistry and the Department of Orthodontics Pedodontics and Community Dentistry

RESULTS

The study involved two hundred and four (204) study casts of orthodontic patients. Out of these, 113 (55.4%) were from female patients. The mean age of the current study was 17 ± 4 years.

The difference in teeth width measurements between the right and left sides of both jaws was not statistically significant (p> 0.05). However, this difference was statistically significant between males and females. The mean, standard deviation, and standard error of estimate of the combined mesio-distal width of lower incisors, and the combined mesio-distal width of maxillary and mandibular canine and premolars are presented in table 1.

Table 1. Descriptive statistics distribution table of the actual mesial-distal width of teeth groups between males and females

Teeth groups	Male (n= 91)			Female (n 113)			t	*p* - value
	Mean (mm)	SD	SEE	Mean (mm)	SD	SEE		
Sum of lower incisors	24.12	1.66	0.17	23.47	1.53	0.14	2.874	0.004
Upper canines and premolars	23.05	1.28	0.13	22.52	1.21	0.11	3.145	0.002
Lower canine and premolars	23.01	1.32	0.14	22.41	1.15	0.11	3.621	0.000

*SD; Standard Deviation, SEE; Standard Error of Estimate, *statistically significance*

Table 2. Comparison between Tanaka-Johnston's measurements and the actual measurements of upper and lower canines and premolar by sex

Gender	Jaw	Predicted measurement		Actual measurement		md	Confidence Interval		*p* - value
		Mean	SD	Mean	SD		Upper	Lower	
Male	Upper jaw	23.06	0.83	23.05	1.25	-0.01	-0.203	0.217	0.944
	Lower jaw	22.56	0.83	23.02	1.29	0.45	-0.66	-0.247	0.000
Female	Upper jaw	22.74	0.76	22.52	1.17	-0.22	0.049	0.39	0.012
	Lower jaw	22.24	0.76	22.41	1.11	0.17	-0.33	-0.01	0.044

md = Mean difference (Actual measurement – predicted measurement), SD = standard deviation, * Statistically significance

Regarding the accuracy of Tanaka–Johnston's method of analysis, there was a statistically significant difference between the predicted measurements and the actual measurements in all groups except in the males' maxillary teeth ($p < 0.05$). This method of analysis underestimated the actual combined width of canine and premolars in the lower jaw by 0.45mm and 0.17mm in males and females, respectively. Moreover, the method overestimated the upper jaw measurement by 0.22mm in females. **(Table 2)**

New regression equations for predicting the combined widths of permanent canine and premolars were developed for the current study using the sum of the lower four permanent incisors as predictors. These predicting equations were generated for the individual sex separately as well as for the combined sex. For the individual sex, the prediction equations for the females' group were Y = 11.39 + 0.47X and Y = 10.97 + 0.49X for the upper and lower jaws, respectively, while for the males' group, they were Y=11.97+ 0.56X for the upper jaw and Y= 10.8 + 0.51X for the lower jaw. On the other hand, the prediction formula for the combined sex was Y = 0.48X + 11.4 and Y = 0.49X + 10.99 for the upper and lower jaws, respectively **(Table 3)**

DISCUSSION

The actual measured widths of canines and premolars for the present study were determined and found to be relatively less than those reported by the **Taiwanese** population [12]. However, they were higher than those reported in Northern India, Turkey, Pakistan and Malaysia.[9,13,14]

Also, they were higher than those reported from other parts of Africa like Libya,[3] Egypt,[15] Kenya[16], Sudan[17] and Uganda[18]. This observation is probably attributed to the difference in race ethnicity and methodologies of these studies. Since the actual measurements from the current study vary significantly from those reported from other populations, it is therefore, important to consider the use of the present findings in planning interceptive procedures in Tanzanian settings as they may be more relevant than those obtained from other populations.

The sum of the lower permanent incisors has been traditionally used in the prediction of the combined width of unerupted canines and premolars in different populations.[8,19] This is so because of the higher correlation between these teeth groups[20]. Likewise, in the current study, the correlation between these teeth groups was significantly high. It

Table 3. Regression parameters for the predictions of the combined mesio-distal width of canines and premolars from the sum of mesio-distal widths of lower incisors

		Coefficient of correlation	Regression coefficients		SEE	(r^2)	*P* value
			a	b			
Male	Upper jaw	0.596	11.97	0.56	1.01	0.36	0.00
	Lower jaw	0.618	10.80	0.51	0.995	0.41	0.00
Female	Upper jaw	0.639	10.97	0.49	0.93	0.38	0.00
	Lower jaw	0.624	11.39	0.47	0.869	0.39	0.00
Combined	Upper jaw	0.623	11.40	0.48	0.97	0.385	0.00
	Lower jaw	0.649	10.99	0.49	0.94	0.421	0.00

Coefficient of determination (r^2), Standard error of the mean (SEE)

ranges from 0.60 for the upper jaw in the male group to 0.65 for the lower jaw for the combined sexes. Studies have shown that a correction coefficient of 0.6 is significant enough for the lower incisors to be used as a predictor of the sizes of unerupted teeth [21]. Since the correlation coefficient of the current study is above this cut-off point, therefore, sum of the lower permanent incisors can also be used as a predictor of the sizes of unerupted teeth in Tanzanian settings. The use of lower incisors as opposed to other types of teeth to predict the sizes of unerupted teeth has substantial clinical advantages. This is because they erupt earlier, they are simple to measure, and they show less size and shape variation [22].

Tanaka-Johnston's method of mixed dentition analysis was not accurate in predicting the size of unerupted teeth in the present study. The inaccuracy in teeth size prediction observed in the present study is supported by reports of several studies, including those from India,[13,23] and those from other parts of Asia like Nepal [22] and Malaysia [24]. Studies from other parties of Africa like Libya [25] and Egypt [26] have also reported about the inaccuracies. Similarly, studies from some East African countries like Kenya, Uganda and Sudan [10,27,28] have reported comparable findings. Considering this reported inconsistency, Tanaka-Johnston's method of mixed dentition analysis is probably relevant only in a few populations.[27,29] Hence, it should be used with caution in different population

New prediction formulas were generated for the present study. These prediction formulas were incomparable with those reported from other populations, including those from East African countries. This indicates that people from the same geographic location may have different teeth sizes. Therefore, care should be taken when adopting a prediction method from other populations regardless of their geographical closeness.

Study Limitations: The data for the current study was collected from one center (MUHAS Dental clinic) located in Dar es Salaam. Although Dar es Salaam is the country's largest business center with a diverse population; and the MUHAS clinic serves as a referral dental center, treating patients from all over Tanzania, the findings may not be exact representation of the Tanzanian population

CONCLUSIONS

Tanaka-Johnston's methods of mixed dentition analysis were found to be inaccurate in estimating the size of unerupted canines and premolars in the current study, therefore, new prediction equations were generated. A larger community-based study design is recommended in the future to assess the applicability of the predictions equation in the general population.

Acknowledgment

The authors wish to acknowledge and thank Dr Joyce Masalu for her assistance in the research methodology and data analysis

Competing Interest

The authors declare no conflict of interest.

Author Contributions

ELD, FMM and MMM contributed to the conception of the study. ELD contributed to data collection, ELD, FMM and MMM contributed to data analysis and manuscript preparation. ELD and FMM contributed to planning and implementing clinical procedures. All authors gave final approval of the version of the manuscript to be published.

REFERENCES AND NOTES

1. Memon S, Fida M. *Comparison of Three Mixed Dentition Analysis Methods in Orthodontic Patients at AKUH*. Vol 20.; 2010.
2. Kondapaka V, Sesham VM, Neela PK, Mamillapalli PK. A comparison of seven mixed dentition analysis methods and to evaluate the most reliable one in Nalgonda population. *Journal of Indian Orthodontic Society*. 2015;49(1):3-9. doi:10.4103/0301-5742.158626

3. Kerosuo H. The role of prevention and simple interceptive measures in reducing the need for orthodontic treatment. *Medical Principles and Practice*. 2002;11(Suppl. 1):16-21.
4. Kondapaka V, Sesham VM, Neela PK, Mamillapalli PK. A comparison of seven mixed dentition analysis methods and to evaluate the most reliable one in Nalgonda population. *Journal of Indian Orthodontic Society*. 2015;49(1):3-9. doi:10.4103/0301-5742.158626
5. Bernabé E, Biostat C, Flores-Mir C, Orth C. *Are the Lower Incisors the Best Predictors for the Unerupted Canine and Premolars Sums? An Analysis of a Peruvian Sample*. Vol 75.; 2005.
6. Lee-Chan S, Jacobson BN, Chwa KH, Jacobson RS. Mixed dentition analysis for Asian-Americans. *American journal of orthodontics and dentofacial orthopedics*. 1998;113(3):293-299.
7. Bugaighis I, Karanth D, Elmouadeb H. Mixed dentition analysis in Libyan schoolchildren. *J Orthod Sci*. 2013;2(4):115-119. doi:10.4103/2278-0203.123197
8. Altherr ER, Koroluk LD, Phillips C. Influence of sex and ethnic tooth-size differences on mixed-dentition space analysis. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2007;132(3):332-339. doi:https://doi.org/10.1016/j.ajodo.2005.08.043
9. Juneja S, Mahajan N, Kaur H, Verma K, Sukhija M, Bhambri E. Comparative evaluation of three mixed dentition analyses and formulation of regression equations for north Indian population: A cross-sectional study. *Biomed J*. 2015;38(5):450-455. doi:10.4103/2319-4170.161333
10. Rita SN, Hasan M, Dhar PP, Abrar MH, Sadat SA. Pattern of Malocclusion in Patients Attended in Orthodontic Department of a Tertiary Level Hospital. *J Bangladesh Coll Phys Surg*. 2019;37(3):119-123. doi:10.3329/jbcps.v37i3.41733
11. 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(4):798-801. doi:10.14219/jada.archive.1974.0158
12. Chong SY, Aung LM, Pan YH, Chang WJ, Tsai CY. Equation for tooth size prediction from mixed dentition analysis for taiwanese population: A pilot study. *Int J Environ Res Public Health*. 2021;18(12). doi:10.3390/ijerph18126356
13. Bernabé E, Biostat C, Flores-Mir C, Orth C. *Are the Lower Incisors the Best Predictors for the Unerupted Canine and Premolars Sums? An Analysis of a Peruvian Sample*. Vol 75.; 2005. http://meridian.allenpress.com/angle-orthodontist/article-pdf/75/2/202/1376772/0003-3219
14. Sharma P, Vedprakash SR, Subhash V, Rastogi S. TANAKA-JOHNSTON MIXED DENTITION ANALYSIS FOR INDIAN POPULATION. *European Journal of Molecular & Clinical Medicine*. 2021;8(3):3547-3557.
15. Melgaço CA, Araújo MT, Ruellas ACO. Applicability of three tooth size prediction methods for white Brazilians. *Angle Orthod*. 2006;76(4):644-649.
16. Kerre N, Ngesa JL, Ng'ang'a P, Kemoli AM, Bermudez J, Seminario AL. Comparison of measured and predicted mesiodistal tooth-widths of 13–17 years old Kenyans: a descriptive cross-sectional study to develop a new prediction equation for use in the mixed dentition in a Kenyan population. *BMC Oral Health*. 2022;22(1):1-6. doi:10.1186/s12903-022-02368-y
17. Buwembo W, Kutesa A, Muwazi L, Rwenyonyi CM. Prediction of width of un-erupted incisors, canines and premolars in a Ugandan population: A cross sectional study. *BMC Oral Health*. 2012;12(1). doi:10.1186/1472-6831-12-23

18. Alzubir AA, Abass S, Ali MAE. Mixed dentition space analysis in a Sudanese population. *J Orthod*. 2016;43(1):33-38. doi:10.1179/1465313315Y.0000000021
19. 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(4):798-801. doi:10.14219/jada.archive.1974.0158
20. Memon S, Fida M. Comparison of three mixed dentition analysis methods in orthodontic patients at AKUH. *Journal of the College of Physicians and Surgeons Pakistan*. 2010;20(8):533-537.
21. Dmd NSL, Dmd MM alice, Dds TLD, Dmd KN, Dds F mir C. The validity and reliability of mixed-. *The Journal of the American Dental Association*. 2011;142(10):1143-1153. doi:10.14219/jada.archive.2011.0083
22. Gyawali R, Shrestha BK, Yadav R. Mixed dentition space analysis among Nepalese Brahmins/Chhetris. *BMC Oral Health*. 2016;17(1). doi:10.1186/s12903-016-0265-1
23. Chong SY, Aung LM, Pan YH, Chang WJ, Tsai CY. Equation for tooth size prediction from mixed dentition analysis for taiwanese population: A pilot study. *Int J Environ Res Public Health*. 2021;18(12). doi:10.3390/ijerph18126356
24. Mahmoud BK, Abu Asab SHI, Taib H. Accuracy of Four Tooth Size Prediction Methods on Malay Population. *ISRN Dent*. 2012;2012:1-4. doi:10.5402/2012/523703
25. Bugaighis I, Elmouadeb H, Karanth D. Mixed dentition analysis in Libyan schoolchildren. *J Orthod Sci*. 2013;2(4):115. doi:10.4103/2278-0203.123197
26. Hammad SM, Abdellatif AM. Mixed dentition space analysis in Egyptian children. *Pediatric Dental Journal*. 2010;20(2):115-121. doi:10.1016/s0917-2394(10)70203-2
27. Hiremath S, Tiwari RV, Shah NR. *Mixed Dentition Space Analysis - First Edition*.; 2021.
28. Thimmegowda U, Niwlikar KB, Khare V, Prabhakar AC. Applicability of Tanaka Jhonston Method and prediction of mesiodistal width of canines and premolars in children. *J Clin Diagn Res*. 2017;11(6):ZC16.
29. John DA. Need for Interceptive Orthodontic treatment in Children of Chennai–A Pilot Study. *Journal of Pharmaceutical Sciences and Research*. 2019;11(12):3757-3760.