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Research Report

Applicability of Moyers and Tanaka-Johnston analyses for the Arab population of Pekalongan, Indonesia

Fani Tuti Handayani and **Rizki Amalia Hidayah**
School of Dentistry,
Faculty of Medicine, Universitas Jenderal Soedirman,
Purwokerto – Indonesia

ABSTRACT

Background: *The Moyers and Tanaka-Johnston analyses, both of which were developed through research into the Nordic-Caucasoid population, constitute the most widely used non-radiographic mixed dentition analyses. Application of these prediction methods to other populations has been extensively investigated, although their suitability to the Arab population resident in Indonesia has rarely been studied.* **Purpose:** *This study aimed to investigate the reliability of Moyers and Tanaka-Johnston analyses of the Arab population of Pekalongan, a city in Central Java, Indonesia.* **Methods:** *This research constituted an observational study incorporating a cross-sectional design of 33 subjects who willingly signed an informed consent form. Their actual tooth size was determined in accordance with the inclusion criteria and then compared with the predictive tooth size values of the Moyers and Tanaka-Johnston analyses.* **Results:** *Comparison of mean values indicated that the predictive values of Moyers 75% (YM) and Tanaka-Johnston (YT) were higher than the actual value (Y). The reliability test result confirmed a value of k = 0.026 for the Y-YM ratio; and k = 0.025 for YT-Y ratio. The calculation results for the mandible indicated a k-value of 0.000 for both types of comparisons between YM-Y and YT-Y. The Moyers 75% prediction for maxilla had a higher reliability value than that of Tanaka-Johnston. The Shapiro-Wilk normality test applied to Y, YM, and YT in the maxilla and mandible indicated that data was normally distributed (sig > 0.05). A Levene's test of homogeneity was conducted and produced homogeneous data (sig > 0.05) with values of 0.333 for Y, 0.516 for YM, and 1.000 for YT. An ANOVA test showed Y-YM and Y-YT to have insignificant differences (p<0.05).* **Conclusion:** *The Moyers 75% and Tanaka-Johnston analyses were reliable because the values produced differed slightly from the actual values. This study concluded that Moyers and Tanaka-Johnston analyses remain valid means of calculating mixed dentitions.*

Keywords: *Arab population; mixed dentition analysis; Moyers method; Tanaka-Johnston method*

Correspondence: Fani Tutihandayani, School of Dentistry, Faculty of Medicine, Universitas Jenderal Soedirman, Jl. Dr. Soeparno Karangwangkal, Purwokerto, Jawa Tengah 53123, Indonesia. E-mail: fanitutihandayani@gmail.com

INTRODUCTION

The mixed dentition period involves transition from primary to permanent teeth characterized by eruption of the first mandibular incisors or the first molars.[1] This period has been widely employed by researchers to predict the size of future permanent teeth and the availability of the jaw arch space.[1] Early detection of conformity of the jaw arch space and tooth size can be a reference for orthodontic intervention and correction in the prevention and treatment of malocclusion.[1,2]

Mixed dentition analysis methods can be categorized into three groups, namely; regression equations, radiographic examination, and a combination of both these methods.[2] The most widely used mixed dentition analysis method, the Moyers and Tanaka-Johnston analysis, is one that utilises the mesiodistal size regression equation of erupted teeth.[3,4] This analytical tool was developed from measurements of the teeth of North American children (Nordic-Caucasoid).[4] The applying of Moyers prediction tables and Tanaka-Johnston equations to other populations around the world can be adjusted by considering the results of tooth size

analysis studies in these populations.[3,5] The accuracy of the predicted size of teeth that will occupy the jaw arch is a determining factor in the early detection of malocclusion and formulation of an orthodontic treatment plan.[4,5] The differing tooth size variations between one population and another causes the reliability of these two methods to be evaluated, especially in populations with typical jaw characteristics and tooth size.[6,7]

One population with distinctive characteristics in the jaw and dentition is that of the Arabs[8,9] who have settled in various parts of Indonesia, especially on Java, constituting the second largest immigrant population within the country. The largest Arab population in Central Java Province is resident in Pekalongan, specifically a village consisting of three districts, namely; Sugihwaras, Klego, and Poncol.[9–11] Analyses of the mixed dentition within this group of Arab ethnicity have rarely been conducted. Therefore, this study aimed to investigate the reliability of the Moyers and Tanaka-Johnston model in conducting such an analysis.

MATERIALS AND METHODS

This study was jointly approved by the Health Research Ethics Commitee of Dr. Moewardi General Hospital and the School of Medicine, Sebelas Maret University of Surakarta (No:420/V/HREC/2016). Research consisting of an observational study with cross-sectional design was conducted between July and December 2016. The inclusion criteria applied in the course of subject selection were as follows: Arab residents of Pekalongan aged between 13 and 14 years old. All permanent teeth (with the exception of the second and third molars) should be present in the oral cavity and fully erupted in both the maxillary and the mandibular arches. All teeth presented normal morphology without any extensive caries or restorations including the mesiodistal edge or interproximal fractures. Children with congenital craniofacial anomalies or previous histories of orthodontic treatment were excluded from the study.

The subjects were students of the Ma'had Islamiyah and Al Irsyad Junior High Schools. The selection of these two educational institutions was based on a preliminary study confirming them to be ones largely attended by 13-14 year old children of Arab descent. The total subject population comprised 33 children, consisting of 12 males and 21 females. An impression was made of the maxilla and mandible of each subject prior in order to manufacture study models which were then analysed at the Basic Dental Science Laboratory of the School of Dentistry, Faculty of Medicine, Jenderal Soedirman University. Standard mixed dentition analysis procedures were implemented in accordance with the methods proposed by Rao.[1] First, measurement of the study model was completed by drying the positive moulds of the maxilla and mandible and cleaning the remnants (nodules) of casts to render them suitable for this purpose. The study models were subsequently coded on the basis of the data of the subject

to which they related and subsequently measured, with each result being recorded in a log according to the data code of each individual.

The first measurement was of the mesiodistal width of the four permanent mandibular incisors, followed by that of the mesiodistal width of canines and the first premolars and second premolars of the left and right maxilla and mandibles. Measurement of the mesiodistal width of the teeth was performed by placing the two ends of a sliding calliper parallel to the dental axis. The measurement taken was checked according to a method suggested by Lundstorm, whereby a single investigator takes all the measurements after carefully marking the maximum mesiodistal width on the relevant teeth and then re-measures a number of randomly selected casts.[12] The results were recorded as preliminary data until all the study models had been measured.

The results of this study include X and Y values. X represents the measurement value of the four mandibular incisors that serve as predictors for the maxillary and C-P1-P2 mandibular values within 75% Moyers and Tanaka-Johnston predictions. Y constitutes the actual measurement of the maxillary and C-P1-P2 mandibular. In this study, the predictive value of the C-P1-P2 for the 75% Moyers is referred to as YM, while the Tanaka-Johnston predictive value is known as YT.

The first calculation involved predicted the number of canines, first premolar and second premolar dimensions, using the Moyers table at 75% percentile using a predictor of the mesiodistal size of the four mandibular incisors. The second calculation was based on the actual count of the size of the canines, first premolar, and second premolar of the Arab population in Pekalongan which were determined as predictors using the Moyers table at 75% percentile, to quantify the mesiodistal size of the four mandibular incisors. The third calculation was completed by measuring the number of canines, first premolars, and second premolars by means of the Tanaka-Johnston equation.

The data obtained was analysed using the Statistical Product and Service Solutions (IBM SPSS Software) version 20.0. The correlation between X and Y was assessed using Pearson's correlation analysis. Data is expressed as mean ± standard deviation (SD). A Kappa (k) reliability test and a Shapiro-Wilk normality test (p>0.05) were both performed, while homogenity was assessed by means of a Levene's test (p>0.05). A comparison of the Y-YM and Y-YT analyzes was conducted using an ANOVA test (p<0.05).

RESULTS

In this study, the mesiodistal size of four mandibular incisors (X) and the mesiodistal size of the C-P1-P2 teeth as measured (Y) resulting in respective values of 0.656 and 0.613 for the maxilla and mandible. This value indicated a linear relationship between the size of four mandibular

incisors with that of the C-P1-P2 teeth. Table 1 shows that the comparison between the average 75% Moyers and Tanaka-Johnston predictive value was higher than the actual value. The mean and standard deviations Y, YM, and YT are presented in Table 1, while the comparison of Y, YM and YT value distribution in the maxilla and mandible are contained in Figure 1 and Figure 2.

A Kappa (k) reliability test comparing the actual value (Y) and 75% Moyers predictive value or Tanaka-Johnston predictive value was performed. The calculation results of the maxilla showed that the comparison between the 75% Moyers predictive value with the actual value of C-P1-P2

in this study was k = 0.026, while the comparison between the Tanaka-Johnston predictive value the actual value C-P1-P2 was k = 0.025. The calculation results for the mandible showed a k-value = 0.000 for a comparison of both 75% Moyers and Tanaka-Johnston predictive values with the actual value. These results indicated that the reliability of 75% Moyers and Tanaka-Johnston prediction was sufficient for measurements of the maxilla but not for those relating to the mandible.

The results of the Shapiro-Wilk normality test between Y, YM, and YT relating to the maxilla and mandible presented in Table 2 confirmed the data as normally

**Table 1.** Mean and standard deviations of Y, YM and YT

	Jaw	Mean	Standard deviation
Y	Maxilla	21.8024	0.97175
	Mandible	20.6215	0.88756
YM	Maxilla	22.4641	0.76534
	Mandible	21.7853	0.84212
YT	Maxilla	22.1812	0.70415
	Mandible	21.6812	0.70415

Table 2. Shapiro-Wilk normality test

	Jaw	Sig.
Y	Maxilla	0.117
	Mandible	0.056
YM	Maxilla	0.255
	Mandible	0.177
YT	Maxilla	0.613
	Mandible	0.613
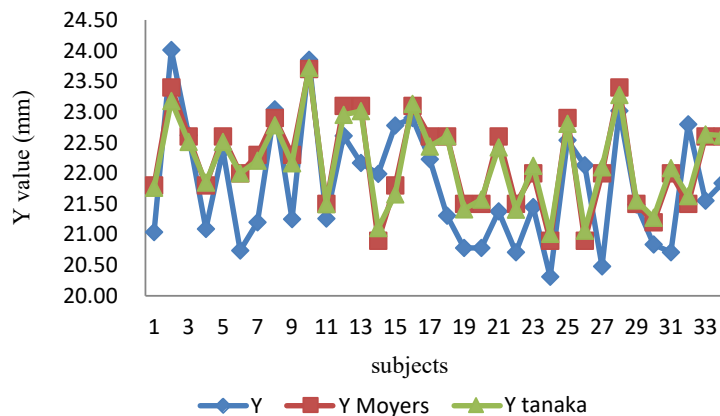
Figure 1. Comparison of Y, YM and YT value distribution in the maxilla.
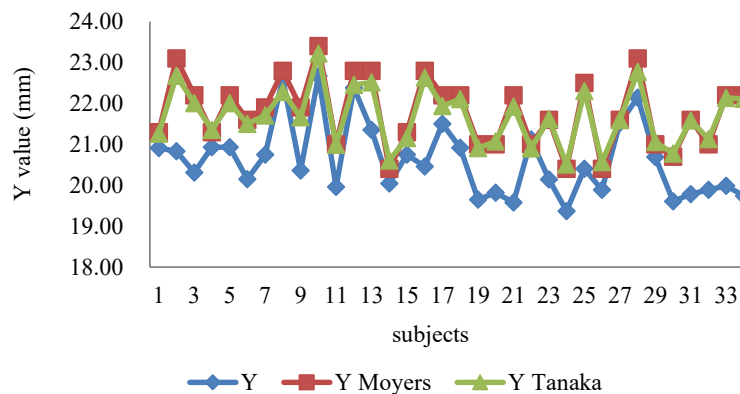
Figure 2. Comparison of Y, YM and YT value distribution in the mandible.

distributed (sig>0.05). Homogeneity was assessed using a Levene's test which produced data (sig > 0.05) with values of 0.333 for Y, 0.516 for YM, and 1.000 for YT.

The ANOVA test results produced a p-value = 0.069 for Y-YM and p = 0.051 for Y-YT (p<0.05) which indicated insignificant differences in both comparisons. This study indicated a constant value of (a) = 11.684 for the maxilla and 11.9834 for the mandible. This value was higher than the predictive constant of 75% Moyers and Tanaka-Johnston, while the regression coefficient of (b) was lower than the 75% Moyers and Tanaka-Johnston prediction, which stood at 0.4525 for the maxilla and 0.3864 for the mandible. The following constitute the equations employed in this study for the purposes of prediction: maxilla with Y = 11.6854 + 0.4525X and mandible with Y = 11.9834 + 0.3864X.

DISCUSSION

The development of dento-craniofacial structures in Arab population is unique compared to other races,[8] with a tendency to protrusion of the incisors as they age. If left untreated at an early stage, they can cause malocclusion. It was revealed that Arabs have a higher convex profile with reduced chin prominence, steeper mandibular plane angle, and greater bimaxillary protrusion.[9] Even within those Saudi ethnic groups with well-balanced faces, there were some fundamental variations in the craniofacial structure of Saudi Arabs.[13] Malocclusion should be treated early during the mixed dentition period, by detecting a discrepancy in tooth size that occurs during that period.[1]

Mixed dentition analysis methods can be categorised into three groups, namely; those utilising regression equations; those involving radiographic examination; and a combination of both methods.[2] The most widely employed mixed dentition analysis method is one that utilises the mesiodistal size regression equation of erupted teeth, namely the Moyers and Tanaka-Johnston analysis.[3,4]

In this study, the actual measurements of the C-P1-P2 size of both the maxilla and mandible in the Arab population proved to be lower than the predicted 75% Moyers and Tanaka-Johnston values. The same result was also produced by previous studies conducted among the Belgaum population in Karnataka, India[14] and the population of Bangalore.[15] Similar results were produced by studies conducted amongst school children in Mumbai.[16] Prediction of C-P1-P2 size in orthodontic treatment influences determination of the treatment plan that will be developed for the patient. Consideration for skeletal expansion during growth and development is one of the treatment plans based on an analysis of space requirements which suggests that the C-P1-P2 size exceeds the available space. Overestimation of the size of C-P1-P2 can result in excess space in the future leading to malocclusion. A comparison of the distribution of Y, YM, and YT values for each jaw is contained in the following figures. Figure

1 features a comparison of the distribution of Y, YM, and YT maxillary values, while Figure 2 shows a comparison for the mandible.

The results of this study indicated the reliability of 75% Moyers and Tanaka-Johnston prediction was sufficient for measurement of the maxilla, but inadequate for the mandible. 75% Moyers prediction for maxilla had a higher reliability value than Tanaka-Johnston. These results were consistent with research conducted among the population of south India.[17] However, different results were produced studies conducted among school children from Medellin in Colombia which found that the 75% Moyers data was more accurate in predicting the mandible measurement value, whereas the Tanaka-Johnston predictive value was more accurate in predicting the maxilla measurement value.[18]

Research conducted by Thimmegowda *et al.* (2017), suggested that the original Tanaka-Johnston method of analysis had overestimated the local Bangalore population and that, consequently, a new regression equation should be formulated. New regression equations and prediction tables were derived for males and females separately, which should be more conveniently employed chairside by the clinician.[15] The results of that study were consistent with those of the research reported here, although the difference between the actual and predicted values of the Tanaka-Johnston analysis were not statistically significant.

Even though the same results were found in the study conducted by Asiry *et al.* (2014),[19] that author stated that further work on a large representative sample from various Arab populations around the world is required in order to draw a firm conclusion. Differences in location can cause racial assimilation potentially leading to differences in physical features of the same race, due to physiological adaptation processes.

The study conducted by Galvão *et al.* (2013),[6] stated that the Moyers mixed dentition analysis should be employed judiciously because its accuracy regarding the probability level remained questionable. The difference between the actual and predicted values of the Moyers 75% analysis in this study was not statistically significant. However, the reliability variations of Moyers and Tanaka-Johnston prediction require numerous researchers to develop regression equations similar to those formulated for this study according to the populations studied.[7]

In this study, comparative tests could not be performed to assess the tendency of one analysis to be superior in predicting the C-P1-P2 value. However, the insignificant differences resulting from the interpretation of data in this study indicated that the Moyers and Tanaka-Johnston analysis remains deployable in the calculation of mixed dentition analysis.

In the study conducted by Connor *et al.*,[20] no significant differences between the SN-FH measurement of Arabs and North American Caucasians were identified. Meiners asserted that the Caucasian race encompassed all of the ancient and most of the modern native populations of Europe, in addition to the aboriginal inhabitants of West

Asia (including the Phoenicians, Hebrews and Arabs).[21] Rawlani *et al.* (2017),[22] also stated that Arabs have a tooth morphology which is classified as Caucasoid. It can be concluded that a Moyers 75% and Tanaka-Johnston analysis was sufficently reliable for mixed dentition analysis of the Arab population of Pekalongan. New regression equations and predictions based on the population studied remain prerequisites to the obtaining of more acurate predictive values.

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