folia medica

Folia Medica 66(4):521-527
DOI: 10.3897/folmed.66.e126997

Original Article

Reliability of Moyer's and Tanaka Johnston's Prediction Methods in a Non-Caucasian Heterogeneous Population – a Cross-Sectional Study

Panchatcharam Barkavi[1], Mohamed Iqbal[2], Priyanka Gandhi[1], Harishma Sivakumar[1], Kavitha Mathivanan[3], Kothandaraman Thirivikhraman[4]

[1] *Chettinad Dental College and Research Institute, Chennai, India*
[2] *Tamilnadu Government Dental College and Hospital, Chennai, India*
[3] *Madha Dental College and Hospital, Chennai, India*
[4] *Sri Venkateswara Dental College and Hospital, Chennai, India*

Corresponding author: Panchatcharam Barkavi, Chettinad Dental College and Research Institute, Chennai, India; Email: barkavi.dent@gmail.com

Received: 8 May 2024 ♦ **Accepted:** 1 August 2024 ♦ **Published:** 31 August 2024

Citation: Barkavi P, Iqbal M, Gandhi P, Sivakumar H, Mathivanan K, Thirivikhraman K. Reliability of Moyer's and Tanaka Johnston's prediction methods in a non-Caucasian heterogeneous population – a cross-sectional study. Folia Med (Plovdiv) 2024;66(4):521-527. doi: 10.3897/folmed.66.e126997.

Abstract

Introduction: Mixed dentition analyses are used to determine possible tooth-size and arch-length discrepancies during the transition from primary to permanent dentition. Prediction methods using a probability table or linear regression equation use the sum of the mesiodistal widths of mandibular permanent incisors to predict the mesiodistal width of unerupted permanent teeth. Racial and sexual variations and sexual dimorphism in tooth size have been reported. The objective of this study is to validate Moyer's and Tanaka Johnston's mixed dentition analyses in a contemporary South Indian population.

Materials and methods: 100 pairs of permanent dentition models belonging equally to both sexes with an age range of 12–21 years comprised the sample in which both analyses were done. The predicted width of permanent canines and premolars was compared to the actual width in the study models.

Results: There was a statistically significant difference between the two values for Moyer's analysis in the mandibular teeth of females (p=0.04), 95% CI −0.605 to −0.969. There was a statistically significant difference between the two values for Tanaka Johnston's analysis of maxillary teeth (p=0.001), 95% CI 0.863 to 1.370.

Conclusions: Moyer's analysis shows a statistically significant underestimation in the mandibular arch of females. Tanaka Johston's analysis shows a statistically highly significant overestimation in the maxilla. Both analyses cannot be reliably applied to the South Indian population.

Keywords

mixed dentition analysis, non-radiographic methods, prediction methods, validity of Moyer's prediction method, validity of Tanaka-Johnston's prediction method

INTRODUCTION

Preventive and interceptive procedures are integral to early treatment protocols in patients with favorable morphogenetic patterns. Maintaining arch length in these individuals is crucial to making sure the transition from deciduous to permanent dentition is uneventful.[1] Mixed-dentition analyses are essential diagnostic tools in this regard. They assess the space available in the arch compared to the space required to accommodate the unerupted permanent canine, first and second premolars.[2] The space required being the sum of the mesiodistal width of an unerupted permanent canine, the first and second premolars are measured by several methods like using radiographs[1], prediction tables[3], and linear equations[4]. The radiographic method is the least precise owing to projection and magnification errors.[5] Analysis by Moyer based on prediction tables[3] and Tanaka and Johnston's equation method[4] are the most frequently used methods to predict the sum of the mesiodistal width of unerupted permanent canines, first and second premolars. Both methods use the mandibular permanent incisors to predict the sum of mesiodistal width of an unerupted permanent canine, first and second premolars. These standards are derived from the American-Caucasian population. However, racial variations[6,7], secular variations[8,9], and sexual dimorphism[10] in tooth sizes have been established. Application of these standards in non-American, non-Caucasian population is questionable. Prediction tables and linear equations for several populations and ethnic groups have been proposed.[11-13] No such standards have been established for the South Indian population. The objective of this study was to validate Moyer's and Tanaka Johnston's mixed-dentition analyses in a contemporary south Indian population for predicting the sum of the mesiodistal width of permanent canines, first and second premolars.

MATERIALS AND METHODS

This is a retrospective, analytical, cross-sectional, record-based study, approved by the institutional review board of the Tamil Nadu Government Dental College and Hospital in Chennai. The sample is from pre-treatment maxillary and mandibular permanent dentition study models (**Fig. 1**) belonging to south Indian patients with homogeneous lineages from two previous generations. The subjects belonged to various states of south India, viz., Tamil Nadu, Karnataka, Kerala, and Andhra Pradesh. Non-probability purposive sampling was used to arrive at 100 samples equally distributed between both sexes and in the age range of 12 to 21 years.

Inclusion criteria

1. Study models with fully erupted permanent incisors, canines, premolars and first molars on both sides of maxillary and mandibular dental arches. The teeth should have reached the occlusal plane to facilitate accurate measurement.
2. Intact dentition with no proximal caries, restorations, and trauma.
3. Mesial and distal contact points of all teeth should be accessible for sliding calipers.
4. Teeth younger than 21 years of age at the beginning of the study in order to exclude the mesiodistal loss of tooth structure due to physiological attrition.

Figure 1. Study models.

Exclusion criteria

1. Teeth with anomalies in form, number, and structure.
2. Study cast with previous history of orthodontic treatment.

The mesiodistal width of mandibular incisors, maxillary and mandibular permanent canines, and the first and second premolars was measured using a digital Vernier caliper (0-150 mm, INSIZE with 0.01 mm resolution) (**Fig. 2**). The greatest mesiodistal measurement from the anatomic mesial contact point to the anatomic distal contact point was

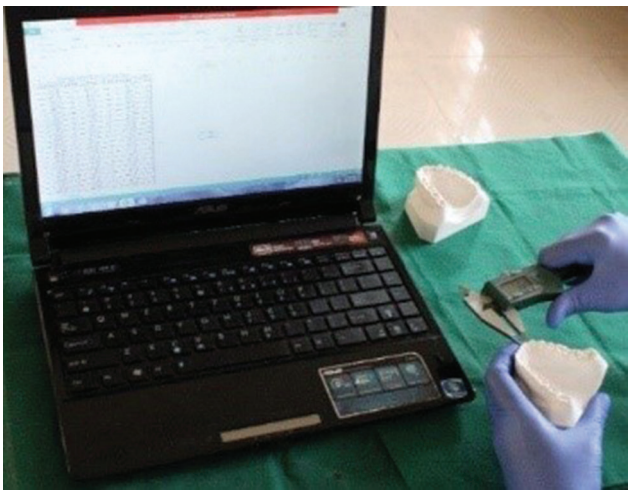

Figure 2. Measuring methods.

considered the mesiodistal width of a tooth. In the absence of contact points, the mesiodistal width was obtained by measuring points where contact with the neighboring teeth would normally occur.[14] If the measurement of sum mesiodistal width of canine and premolars on both sides shows a difference of more than 0.2 mm, an average of the two was taken as the sum.[7] All the measurements were recorded by a single examiner. Intra-examiner error was reduced by repeated measurements till errors were reduced to a minimum of 1%. Reliability was predetermined at 0.2 mm.[7] A coefficient of reliability was calculated randomly for every fifth cast. Values for *r* greater than 0.5 indicated good reliability. The predicted width of permanent canines and premolars in both arches were determined using the prediction table in Moyer's analysis and the linear equation in Tanaka Johnston's method.

Statistical analysis

Statistical analysis was done by IBM SPSS (IBM Corp. Released 2011.IBM SPSS Statistics for Windows, Version 20.0 Armonk, and NY: IBM Corp). Mean and SD were used to summarize the data. Means and standard deviations for the sum of the mesiodistal width of the mandibular incisors and the sum of mesiodistal width of permanent canine and premolars in a quadrant were determined. Means and standard deviations for the predicted width of permanent canines and premolars in both arches were also determined. Initially, the data was checked for normality using the Shapiro-Will test. The data was found to be normal, and therefore it was decided to use parametric tests for further comparisons. Predicted and measured values were compared using the Student's t test. A *p* value of less than 0.05 was considered statistically significant.

RESULTS

The intra-examiner measurements showed a strong reliability with Cohen's Kappa value of 0.859 (p=0.002) **(Table 1)**. The difference in right and left side measurements were statistically insignificant for both maxillary (p=0.952) and mandibular (p=0.923) arches **(Table 2)**. In Moyer's analysis at the 75th percentile, the mean differences between the actual and predicted values of the sum mesiodistal width of permanent canines, first and second premolars, for the female sample in the maxilla were 0.07 mm **(Fig. 3)** and 0.6 mm in the mandible **(Fig. 4)**. The value was statistically significant in the mandible (p=0.04, 95% CI −0.605 to −0.969) and statistically insignificant in the maxilla (p=0.665, 95% CI −0.06714 to −0.37369) **(Table 3)**. In the male sample, these values were 0.3 mm in the maxilla

Table 1. Cohen's kappa statistics

Variable	Value	P value
Cohen's kappa	0.859	0.002*

*Significant at 5% level of significance (p<0.05)

Table 2. Statistical analysis for comparison of right side and left side mesiodistal width of canines and premolars

Arch	Side	Mean	SD	SEM	P value
Maxilla	Left	21.6775	1.074	0.107	0.952
	Right	21.6803	1.076	0.107	
Mandible	Left	22.2709	1.240	0.124	0.923
	Right	22.2581	1.241	0.124	

SD: standard deviation; SEM: standard error mean

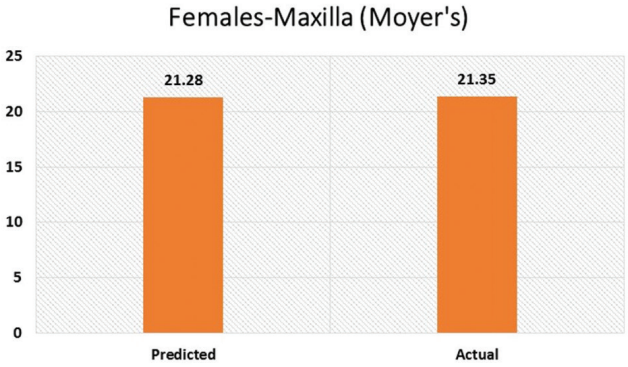

Figure 3. Mean differences between the actual and predicted values of the sum mesiodistal width in the maxilla (females) (Moyer's analysis).

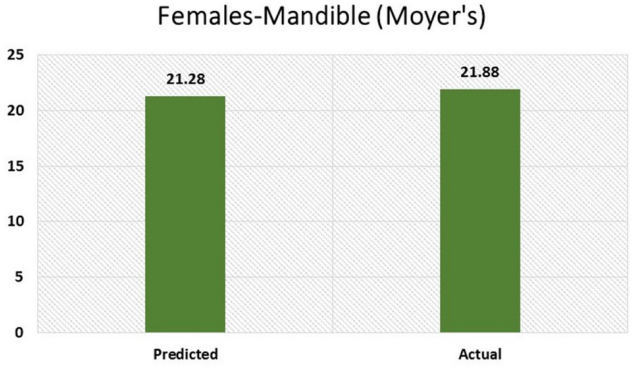

Figure 4. Mean differences between the actual and predicted values of the sum mesiodistal width in the mandible (females) (Moyer's analysis).

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Table 3. Moyer's prediction analysis in males and females' maxilla and mandible

Variable		Group	Mean	SD	SEM	95% Confidence interval of the difference		P value
						Lower	Upper	
Female	Maxilla	Predicted	21.28	0.331	0.047	−0.06714	−0.37369	0.665
		Actual	21.35	1.02	0.146			
	Mandible	Predicted	21.28	0.602	0.086	−0.60531	−0.96916	0.04*
		Actual	21.88	1.13	0.161			
Males	Maxilla	Predicted	22.27	0.595	0.086	−0.29950	−0.71046	0.151
		Actual	22.57	1.29	0.184			
	Mandible	Predicted	22.08	0.536	0.079	0.09035	−0.24666	0.59
		Actual	21.99	1.02	0.146			

*Significant at 5% level of significance (p<0.05); SD: standard deviation; SEM: standard error mean

(Fig. 5) and −0.09 mm **(Fig. 6)** in the mandible. In both arches, these differences were statistically insignificant in the maxilla (p=0.151, 95% CI −0.29950 to −0.71046) and in mandible (p=0.59, 95% CI 0.09035 to −0.24666) **(Table 3)**. In Tanaka and Johnston's analysis, the mean difference between the actual and predicted sum mesiodistal width was −1.11 mm in the maxilla **(Fig. 7)** and −0.03 mm in the mandible **(Fig. 8)**. These differences were statistically highly significant in the maxilla and statistically insignificant in the mandible (p=0.001, 95% CI 0.86365 to 1.37065 and p=0.81, 95% CI −0.24726 to 0.31536, respectively) **(Table 4)**.

DISCUSSION

Non-radiographic mixed-dentition analyses to predict the sum of the mesiodistal width of unerupted permanent canines, first and second premolars are based largely on odontometric data of early white North American children of European ancestry. Racial and secular variations, sexual dimorphism exhibited by human dentition makes applicability of these norms in other populations unreliable. Several studies have been carried out in Middle Eastern, African, and European populations.[7,12,13,15] Studies on Indian population are predominantly restricted to North Indian population[16-18] with few in the homogenous South Indian population[19-21]. This study is an attempt to investigate the applicability of Moyer's and Tanaka Johnston's mixed-dentition analyses in a heterogeneous south Indian population. We restricted the sample age to 21 years to minimize bias attributable to physiological attrition and loss of proximal teeth material. A digital Vernier caliper with 0.01 mm resolution was used to reduce reading errors. Intra-examiner reliability of the study was strong with a Cohen's kappa score of 0.859. The study found that Moyer's analysis underestimated the sum of mesiodistal widths of permanent canines, first and second molars, both in the maxilla and the mandible for female samples, with statistical significance only in the mandible. In the male samples, there was underestimation in the maxilla and overestimation in the mandible, with no statistical significance in both arches. Melgaco et al.[22] showed similar results at the 50th and

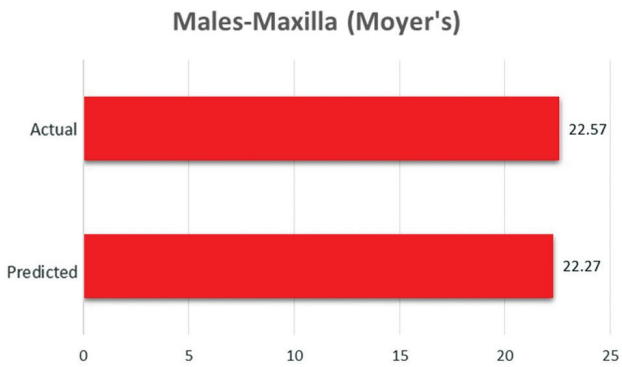

Figure 5. Mean differences between the actual and predicted values of the sum mesiodistal width in the maxilla (males) (Moyer's analysis).

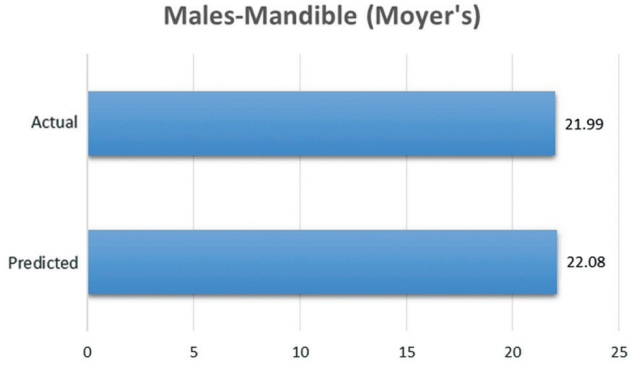

Figure 6. Mean differences between the actual and predicted values of the sum mesiodistal width in the mandible (males) (Moyer's analysis).

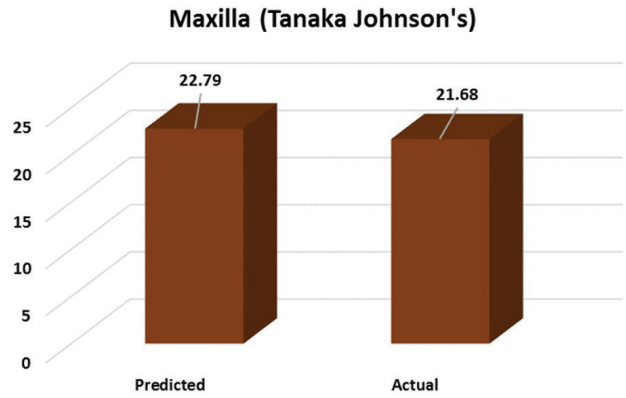

Figure 7. Mean differences between the actual and predicted values of the sum mesiodistal width in the maxilla (Tanaka and Johnston's analysis).

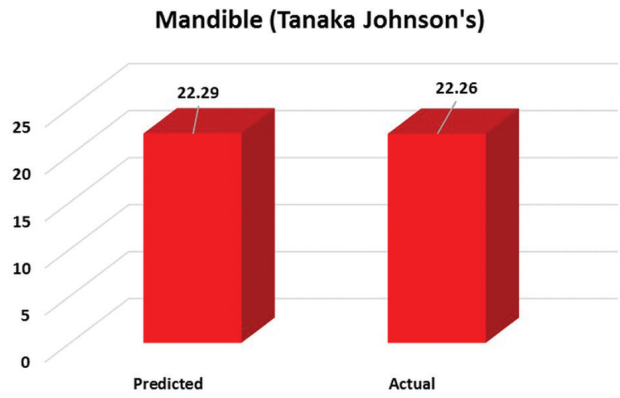

Figure 8. Mean differences between the actual and predicted values of the sum mesiodistal width in the mandible (Tanaka and Johnston's analysis).

Table 4. Tanaka Johnsшon's prediction analysis

Variable	Group	Mean	SD	SEM	95% Confidence interval of the difference		P value
					Lower	Upper	
Maxilla	Predicted	22.79	0.7030	0.070	0.86365	1.37065	0.001*
	Actual	21.68	1.076	0.107			
Mandible	Predicted	22.29	0.7039	0.070	−0.24726	0.31536	0.81
	Actual	22.26	1.238	0.123			

*Significant at 5% level of significance (p<0.05); SD: standard deviation; SEM: standard error mean

75th percentile, with statistical significance in both sexes. Philip et al.[16] and Sonahita et al.[17] showed similar results, with statistical significance in both arches. Kommineni et al.[19] in their study on Chennai population found validity in Moyer's at the 50th percentile alone. A similar finding was reported by Kamatham et al.[20] Dasgupta et al.[18] and Legović et al.[23] found statistically significant overestimation of predicted width. With respect to Tanaka Johnston's analysis, this study found overestimation in the maxilla and the mandible. This was statistically significant in the maxilla and insignificant in the mandible. The data was not differentiated between sexes in keeping with the original recommendation. This is similar to studies by Legović et al.[23] and Dasgupta et al.[18] While the few studies on Indian population are homogeneous, this study is a composite heterogeneous study that can be extrapolated to the South Indian population as a whole. The sample size is a limitation of this study.

CONCLUSIONS

Application of mixed-dentition analyses in a non-Caucasian, non-American population based on the sum of the mesiodistal width of mandibular permanent incisors as a predictor requires validation as the norms are Caucasian-American-based. This study was conducted with the objective of such validation in a composite South Indian population.

The salient conclusions are:

Moyer's prediction at the 75th percentile is inaccurate to be applied for a South Indian population.

1. Moyer's analysis shows a statistically significant underestimation in female mandibles and statistically insignificant underestimation in female maxillae and male maxillae.
2. Moyer's analysis shows a statistically insignificant overestimation in male mandibles.
3. Tanaka and Johnston's analysis shows a highly statistically significant overestimation in maxilla and statistically insignificant overestimation in mandible.

Both analyses cannot be reliably applied to the South Indian population, and hence there is a need to frame population-specific norms. This would require another study with a larger sample size to generate data and apply a possible regression model to make the analyses more reliable for this population.

Acknowledgements

The authors have no support to report.

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Funding

The authors have no funding to report.

Competing Interests

The authors have declared that no competing interests exist.

Author contributions

Panchatcharam Barkavi: conceptualization, data curation, methodology, project administration, resources, validation, visualization, writing – original draft, writing – review and editing; *Mohamed Iqbal*: visualization, resources, validation, writing – original draft, writing – review and editing; *Priyanka Gandhi*: writing – original draft, writing – review and editing; *Harishma Sivakumar*: writing – original draft, writing – review and editing; *Kavitha Mathivanan*: writing – original draft, writing – review and editing; Kothandaraman Thirivikhraman: writing – original draft, writing – review and editing.

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Надёжность методов прогнозирования Мойера и Танаки Джонстона в гетерогенной популяции неевропеоидной расы – поперечное исследование

Панчатчарам Баркави[1], Мохамед Икбал[2], Приянка Ганди[1], Харишма Сивакумар[1], Кавита Мативанан[3], Котандараман Тивикраман[4]

[1] *Стоматологический колледж и исследовательский институт „ Четинад", Ченай, Индия*

[2] *Государственный стоматологический колледж и больница „Тамилнаду", Ченай, Индия*

[3] *Стоматологический колледж и больница „Мадха", Ченай, Индия*

[4] *Стоматологический колледж и больница „ Сри Венкатесвара", Ченай, Индия*

Адрес для корреспонденции: Панчатчарам Баркави, Стоматологический колледж и исследовательский институт „Четинад", Ченай, Индия; E-mail: barkavi.dent@gmail.com

Дата получения: 8 мая 2024 ♦ **Дата приемки:** 1 августа 2024 ♦ **Дата публикации:** 31 августа 2024

Образец цитирования: Barkavi P, Iqbal M, Gandhi P, Sivakumar H, Mathivanan K, Thirivikhraman K. Reliability of Moyer's and Tanaka Johnston's prediction methods in a non-Caucasian heterogeneous population – a cross-sectional study. Folia Med (Plovdiv) 2024;66(4):521-527. doi: 10.3897/folmed.66.e126997.

Резюме

Введение: Анализы смешанного прикуса используются для определения возможных различий в размере зубов и длине зубной дуги при переходе от молочного к постоянному прикусу. Методы прогнозирования с использованием таблицы вероятностей или уравнения линейной регрессии используют сумму мезиодистальной ширины постоянных резцов нижней челюсти для прогнозирования мезиодистальной ширины непрорезавшихся постоянных зубов. Сообщалось о расовых и половых различиях и половом диморфизме в размере зубов. Целью данного исследования является проверка анализов смешанного прикуса Мойера и Танаки Джонстона у современного населения Южной Индии.

Материалы и методы: 100 пар моделей постоянного прикуса, принадлежащих в равной степени обоим полам в возрасте от 12 до 21 года, составили выборку, в которой были выполнены оба анализа. Прогнозируемая ширина постоянных клыков и премоляров сравнивалась с фактической шириной в моделях исследования.

Результаты: Была статистически значимая разница между двумя значениями для анализа Мойера в нижних зубах женщин (p=0,04), 95% CI от −0,605 до −0,969. Была статистически значимая разница между двумя значениями для анализа Танаки Джонстона верхних зубов (p=0,001), 95% CI от 0,863 до 1,370.

Заключение: Анализ Мойера показывает статистически значимую недооценку в нижней челюсти у женщин. Анализ Танаки Джонстона показывает статистически высокозначимую переоценку в верхней челюсти. Оба анализа не могут быть надёжно применены к населению Южной Индии.

Ключевые слова

анализ смешанного прикуса, нерентгенографические методы, методы прогнозирования, обоснованность метода прогнозирования Мойера, обоснованность метода прогнозирования Танаки-Джонстона