Evaluation of the Applicability and Reliability of Two Mixed Dentition Analyses in 11-15 Year Old School Children in Sangareddy

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ABSTRACT

Background: *Mixed dentition space analysis is an essential diagnostic procedure used to evaluate whether adequate space is available for the eruption of permanent teeth, identify potential future crowding or spacing concerns, and predict the trajectory of a child's dental development.*

Aim: *To assess the reliability of Moyer's mixed dentition space analysis and Tanaka-Johnston's mixed dentition space analyses among school children in the Sangareddy district of Telangana, India*

Methodology: *After obtaining institutional ethical clearance, 500 subjects fulfilling inclusion criteria were included in the pilot study. Maxillary and mandibular models were obtained from selected children of both sexes. Mesiodistal dimensions of the lower arch incisors and canine-premolars of both upper and lower arches were obtained by measuring the maximum distance between the contact points on the proximal surfaces with a vernier digital caliper.*

Result: *The collected data were analyzed statistically using paired t-tests and ANOVA. The analysis indicated that, for both males and females, the mean values obtained with Moyer's method and Tanaka-Johnston's methods were lower than the actual values in both maxillary and mandibular dental arches. A gender discrepancy was observed, with males displaying significantly larger canine-premolar segments. The standard deviation (SD) of measured values was higher when compared to the estimated values.*

Conclusion: *In the Sangareddy population of Indian origin, Moyer's method and Tanaka-Johnston methods significantly underestimated the mesiodistal widths of the canines and premolars.*

Key words: *Mixed dentition stage, Malocclusion, Moyer's analysis, Tanaka–Johnson analysis*

INTRODUCTION:

Teeth, aside from knives and forks, are crucial tools humans use to cut their food. Occlusion refers to the contact relationship between the maxillary and mandibular teeth, which can be static when the jaw is at rest or centric when the upper and lower teeth are in maximum intercuspation.[1]

Throughout each stage of dental development, occlusion serves as a primary indicator for detecting malocclusion, which is any deviation from normal alignment.[2] Malocclusion often emerges during the transition to mixed dentition. It can lead to issues such as speech difficulties, eating challenges, changes in facial structure, and problems like biting the tongue or cheek. During the mixed dentition phase, accurate predictions can be made regarding future dental growth, helping to anticipate potential issues such as teeth spacing or crowding in the arch.[3]

The mixed dentition stage begins at around 6 years of age with first permanent molars and mandibular incisors eruption into the oral cavity. Addressing potential malocclusion during this stage can mitigate its severity or even prevent it altogether in the future. Before proceeding, it is essential to conduct a space analysis.[4] Mixed dentition analysis assists in evaluating the space needed to align unerupted permanent cuspids and bicuspids within the dental arch.[5] This assessment is crucial for determining the appropriate treatment approach, whether it involves maintaining space, serial extraction, regaining space, eruption guidance, or simply periodic observation of the patient.[6] In his early work, Black (1897) made initial attempts to predict un-erupted teeth mesio-distal dimensions using tables that listed average mesiodistal widths.[7]

Mixed dentition space analysis can be classified into three types: methods using regression equations, methods using radiographs, and methods that combine both approaches. For instance, Moyers method(1958) and Tanaka-Johnston method(1974) employ regression equations to predict the mesiodistal dimensions of unerupted teeth. On the other hand, Nance (1947), Bull (1959), and Huckaba (1964) uses radiographs to measure the mesiodistal dimensions of un erupted teeth. Hixon and Old father (1958), along with Staley and Karber (1980), used both regression equations and radiographic measurements in their methodology.[8]

Moyer's analysis and Tanaka-Johnston's analysis are commonly utilized worldwide.[4] However, these methods have primarily been validated in populations of North European descent. There is a widely held belief that the accuracy of these methods can be affected by secular trends and gender differences when applied to diverse ethnic populations.[9] Balilt and Lavelle observed that tooth dimensions vary according to gender and among different population groups.[10] Therefore, this study aims to assess the applicability and reliability of Moyer's and Tanaka-Johnston method within Sangareddy population.

MATERIALS AND METHODOLOGY:

The ethical approval for this study was secured from the MNR INSTITUTIONAL ETHICS COMMITTEE(MNR/MC-IEC/0023/2022). Permission was obtained from the Principals of Sangareddy district schools to conduct my study. Informed consent was secured from all participants. The cross-sectional study encompassed a sample of 500 individuals, comprising 250 boys and 250 girls, all aged between 11 and 15 years.

The inclusion criteria encompassed subjects with all permanent teeth except third molars, no history of prior orthodontic treatment, absence of congenital craniofacial anomalies and dental anomalies, intact dentition, and age up to 15 years to avoid significant proximal attrition discrepancies. Exclusion criteria included teeth with caries, proximal restorations, wear, or fractures, partially erupted teeth, dental anomalies affecting tooth shape, size, number, or form, and individuals with systemic diseases or serious health conditions.

After the general examination, subjects were selected based on inclusion criteria. Upper and lower arches alginate impressions were taken using perforated stainless steel impression trays (Fig 1a). Type III dental stone study models were then fabricated by pouring the impressions. Using dental plaster bases for study models were created with the aid of a base former (Fig 1b). The mesiodistal dimensions of the canines, premolars, and mandibular incisors were measured with digital calipers, identifying the maximum distance between the contact points on the proximal surfaces (Fig 1c). Expected mesiodistal widths of cuspids and bicuspids were calculated using Moyer's method at 75th percentile and the Tanaka-Johnston method. Statistical analysis was conducted using Statistical Package for Social Sciences version 25.0 (SPSS 25.0).

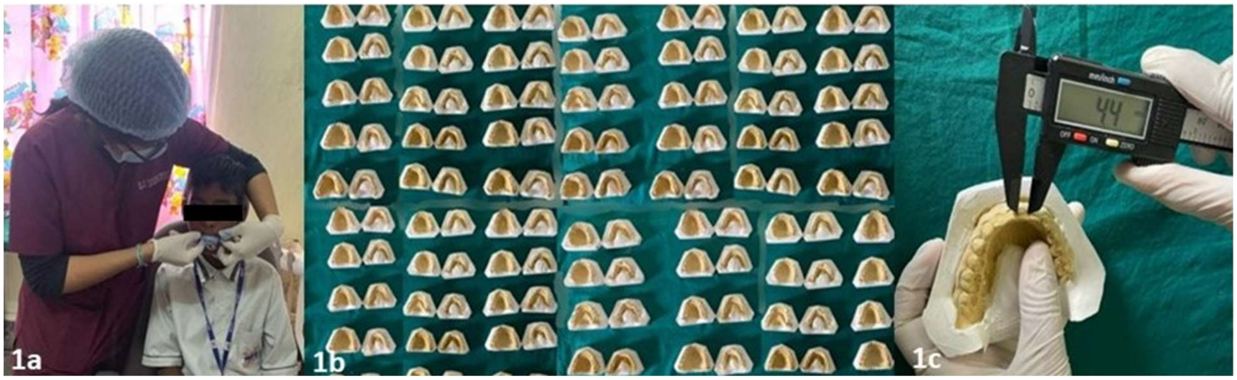

Figure 1: 1a) depicts taking an alginate impression from the subject. 1b) illustrates the display of subject models. 1c) demonstrates the process of taking mesiodistal dimensions using a vernier digital caliper

STATISTICAL ANALYSIS:

The measured and estimated widths derived from Moyer's method and Tanaka–Johnston's method were used to calculate the mean and standard deviation for both sexes. Comparisons and associations were analyzed using paired t-tests and ANOVA tests to evaluate discrepancies between the measured and estimated values and to identify any notable variations between groups.

RESULTS:

In the total sample of 500 individuals, comprising 250 males and 250 females, the distribution by age was as follows: 12 years old are 1.2%, 13 years old are 19.8%, 14 years old are 51.4%, and 15 years old are 27.6%.

Table 1 illustrates the comparison between measured and estimated values using Moyer's method for both genders, assessed with a paired t-test. The mean of the measured values exceeded that of the estimated values in both arches, accompanied by a higher standard deviation for the measured values in both arches. A significant difference was observed in both arches.

Measurement	N	Measured		Moyers		P value
		Mean	SD	Mean	SD	
Maxillary right	500	22.0760	1.03638	21.0494	0.51188	**<0.001***
Maxillary left	500	22.0626	1.20534	21.0494	0.51188	**<0.001***
Mandibular right	500	21.6138	1.13690	20.8596	0.64218	**<0.001***
Mandibular left	500	21.6816	1.15465	20.8596	0.64218	**<0.001***

Table 1: Measured and estimated values of an overall sample using Moyer's method
Paired t-test; $p \leq 0.05$ considered statistically significant

Table 2 illustrates the comparison between measured and estimated values using Tanaka-Johnston method for both genders, assessed with a paired t-test. The mean of the measured values exceeded that of the estimated values in both arches, accompanied by a higher standard deviation for the measured values in both arches. A significant difference was observed in both arches.

Table 2: Measured & estimated values of an overall sample using Tanaka Johnston's method

Measurement	N	Measured		T-J		P value
		Mean	SD	Mean	SD	
Maxillary right	500	22.0760	1.03638	21.6583	0.61457	**<0.001***
Maxillary left	500	22.0626	1.20534	21.6583	0.61457	**<0.001***
Mandibular right	500	21.6138	1.13690	21.1758	0.62356	**<0.001***
Mandibular left	500	21.6816	1.15465	21.1758	0.62356	**<0.001***

Paired t-test; p ≤0.05 considered statistically significant

Table 3: Comparison between males and females

Method	Quadrant	Males		Females		P value
		Mean	SD	Mean	SD	
Direct	Maxillary right	22.2084	1.04899	21.9436	1.00843	**0.006***
	Maxillary left	22.0860	1.32698	22.0392	1.07217	0.644
	Mandibular right	21.8092	1.12673	21.4184	1.11538	**0.001***
	Mandibular left	21.9696	1.11641	21.3936	1.12198	**<0.001***
Moyers	Maxillary right	21.2076	0.59346	20.8912	0.35022	**<0.001***
	Maxillary left	21.2076	0.59346	20.8912	0.35022	**<0.001***
	Mandibular right	21.1160	0.63377	20.6032	0.54107	**<0.001***
	Mandibular left	21.1160	0.63377	20.6032	0.54107	**<0.001***
Tanaka-Johnston's	Maxillary right	21.7182	0.62636	21.5984	0.59782	**0.046***
	Maxillary left	21.7182	0.62636	21.5984	0.59782	**0.046***
	Mandibular right	21.2410	0.64066	21.1106	0.60020	**0.040***
	Mandibular left	21.2410	0.64066	21.1106	0.60020	**0.040***

Independent t-test; p ≤0.05 considered statistically significant

Table 3 shows the comparison between males and females using the Independent t-test. Boys showed larger sizes of teeth than girls in the measured values, estimated values of Moyer's and Tanaka-Johnston methods. Statistically significant values were noticed for all quadrants in all methods except for maxillary left canine and premolars in the direct method.

Table 4 shows the comparison of the mean and standard deviation of actual values, Moyer's prediction values, and Tanaka-Johnston values using the ANOVA test. Statistically significant values were noticed with p-value < 0.001

Table 4: Mean comparison of measured and estimated values

	n	Mean	SD	F value	P value
Direct	500	87.4340	3.67694	132.85	**<0.001***
Moyers	500	83.8180	2.22128		
Tanaka Johnston's	500	85.6682	2.45188		

Repeated Measures of ANOVA; p ≤0.05 considered statistically significant

DISCUSSION:

The mixed dentition phase is pivotal for identifying deviations from normal development and enabling timely correction by assessing tooth size, arch dimensions, and available space.[9] In this phase, performing mixed dentition space analysis is essential in diagnosis and treatment planning. The selection of an accurate method is crucial because inaccuracies in estimating crown dimensions of unerupted cuspids and bicuspids—whether overestimating or underestimating—can significantly impact treatment decisions, especially those involving extractions.[11]

Permanent mandibular incisors and first molars are essential for conducting space analysis, serving as critical guides for orthodontic treatment planning.[9] Mandibular incisors are particularly advantageous for mixed dentition space analysis due to their early eruption in arch, ease of measurement, minimal size variability, lower susceptibility to caries and anomalies, and their pivotal role in space management challenges.[12,13,14] In contrast, maxillary incisors were excluded from predictive procedures due to their variable sizes and lower reliability in predictions.[13] Deciduous teeth were also not considered suitable predictors for the dimensions of unerupted bicuspids and permanent cuspids, given their weaker correlation with permanent teeth and the common occurrence of premature extraction or exfoliation. Therefore, predictions based on deciduous teeth could not be universally applied to all children.[15]

In this study, to avoid potential bias, a maximum age limit of 15 years was set. Beyond this age, individual teeth may undergo significant reduction due to interproximal attrition, and there may also be pathological migration affecting both anterior and posterior teeth, leading to a reduction in arch space as reported.[15]

In the present study, a digital vernier caliper was employed instead of a manual caliper to measure mesiodistal dimensions of teeth, as the manual caliper was prone to inaccurately assessing values on a scale. A digital vernier caliper greatly aids in reducing eye stress and reading errors.[10] Bhatnagar A et al, Ravinthar et al, Srivastava B et al, Sonahita A et al also used a digital vernier caliper in their study for measuring mesiodistal dimensions of teeth[5,9,16,17]

In the study conducted by Bhatnagar A. et al., a gender disparity was observed where the combined mesiodistal dimensions of permanent maxillary cupids and bicuspids, permanent mandibular cuspids and bicuspids were significantly larger in males.[18] Similarly, in our study, sexual dimorphism was noted, with males exhibiting larger mesiodistal dimensions of cuspids and bicuspids compared to females. Statistically significant differences(p < 0.05) were observed in all quadrants, except for the upper left cuspid and bicuspids. Conversely, a study by Singh and Nanda involving 104 sets of dental casts (52 males and 52 females) found no significant difference in tooth size between the sexes. They opted not to segregate tooth size data based on gender.[19]

In our study, we observed that Moyer's method consistently underestimated the mesiodistal dimensions of cuspids and bicuspids in both upper and lower arches for males and females, and this difference was significant statistically(p < 0.001). Similarly, Sonahita A. et al., in their Bangalore study, reported that Moyers' equations underestimated the actual values for males by 0.82 mm in maxillary arch and 0.95 mm in mandibular arch, and for females by 1.22 mm in maxillary arch and 1.45 mm in mandibular arch, all with statistical significance ($p \leq 0.01$).[17] Contrarily, Bhatnagar A. et al. and Maroli S. et al. asserted in their studies that Moyer's method at 75th percentile tended to overestimate the sizes of cuspids and bicuspids.[18,19] They suggested that racial differences between their studies and Moyer's original analysis may account for this discrepancy.[18] Furthermore, Grover N. et al., in their study of the Lucknow population, observed that Moyer's mixed dentition method underestimated the mesiodistal dimensions of cuspids and bicuspids in males but overestimated them in females.[16]

In our study, we observed that Tanaka-Johnston method consistently underestimated the mesiodistal dimensions of cuspids and bicuspids in both arches for males and females, and this difference was significant statistically ($p < 0.001$). Sholapurmath SM et al., in their study on the Jangam population, similarly found that Tanaka-Johnston method underestimated the mesiodistal dimensions of both arches when compared to actual measurements on study casts.[20] Conversely, Abu Alhaija ES et al. observed in their study that the Tanaka-Johnston method underestimated the original sizes of Jordanian teeth dimensions, except for upper arch unerupted cuspids and bicuspids in male subjects. They attributed this difference to racial variations between their study sample and the population used by Tanaka and Johnston.[7]

On the other hand, Al-Bitar ZB et al. found in their research that Tanaka-Johnston method overestimated the mesiodistal dimensions of both arches when compared to actual measurements on study casts ($P < 0.05$).[6] Furthermore, Grover N et al., in their study of the Lucknow population, observed that the Tanaka-Johnston mixed dentition method underestimated the mesiodistal dimensions of cuspids and bicuspids in males but overestimated them in females. They concluded that this method exhibited a statistically significant difference, suggesting its limitations in applicability for the Lucknow population.[16]

Limitations:
Given the restricted size of the study population, additional research with an expanded sample size is justified.
Clinical significance:
Early identification and treatment planning during the mixed dentition phase are critical for anticipating the dimensions of developing cuspids and bicuspids, and evaluating the space available to accommodate them. This stage allows dentists to analyze the developing dentition and make informed decisions regarding the risk of malalignment and potential space loss. By doing so, they can intervene early to guide proper tooth eruption and alignment, which can ultimately prevent more complex orthodontic issues later on.
CONCLUSION:
The following findings were derived from the current study: There were statistically significant and clinically meaningful disparities between the measured and estimated dimensions of cuspids and bicuspids when using Moyer's and Tanaka Johnston methods in this population. A gender disparity was evident in this investigation, with male participants exhibiting notably broader segments of upper and lower cuspids and bicuspids. Our study reveals that current methods of mixed dentition analysis need regular updates to reflect regional trends, racial variations, and gender differences. In the Sangareddy population, these methods tend to underestimate values, necessitating adjustments for more accurate results. Therefore, it is advisable to standardize these assessment criteria specifically for Asian populations. This standardization will assist dentists in devising the most precise treatment plans for children requiring occlusion correction.

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