Section A-Research paper
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Application of Tanaka Johnston and Melgaco Regression Equations Among Nalgonda Population, India

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Abstract

Background: Prediction of mesiodistal widths of unerupted permanent teeth in a specific group of population requires a valid mixed dentition analysis method as tooth dimensions vary with race, gender and ethnicity.

Aim: To evaluate the applicability of Tanaka –Johnston's & Melgaco's regression equations and to derive new regression equations in predicting the mesiodistal widths of unerupted permanent canines and premolars among Nalgonda population.

Materials and methods: A total of 200 children (100 females and 100 males) who have met the selection criteria were included to appraise the applicability of two mixed dentition space analysis MDSA) methods, Tanaka- Johnston's and Melgaco's regression equations among Nalgonda population. Statistical analysis was done using correlation coefficients, independent 't' test, paired 't' test, and ANOVA methods.

Results: When Melgaco's regression equation was applied for this group of population, no significant difference between the actual and predicted widths was observed. Tanaka -

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Johnston's method tended to overestimate the actual widths of canines and premolars and was not accurate for this group of population.

Conclusion: Sum of the mesiodistal widths of mandibular first molar and incisors was found tobe good predictor of widths of unerupted mandibular canines and premolars for this group of population.

Keywords: Prediction, Regression equation, Mixed dentition, Unerupted teeth, Tanaka-Johnston and Melgaco.

Introduction: In Pediatric dentistry, mixed dentition analysis has paramount of importance because multiple changes that occur in the transitional phase of development of dentition and occlusion could further lead to the development of various malocclusions. As tooth size is a determinant of normal occlusion, forecasting arch length - tooth size discrepancies using Mixed Dentition Space Analysis (MDSA) would guide in prevention and early intervention of various developing malocclusions. Hence, the onus of Paediatric dentist is to critically evaluate children with mixed dentition for such discrepancies prior to the eruption of permanent canines and premolars.

Numerous mixed dentition analyses using probability tables[1], radiographs[2], simple regression analysis[3], multiple regression analysis methods and other approaches such as lateral cephalometric radiographs[4] or CBCT[5] have been put forward by various authors for predicting the mesiodistal dimensions of unerupted canines and premolars worldwide. MDSA methods based on linear regression equation of Tanaka – Johnston's[6] and Moyer's[7] analyses methods were reported to be the most accepted methods, in which the sum of the mesiodistal widths of mandibular incisors and probability tables respectively were used for predicting the space discrepancy of dental arches.

The dental literature is replete with researches that were dealt with the applicability of all these analyses methods among different population groups belonging to varieties of races and ethnicities.[8] It was reported that racial and sex- specific MDS analyses might require revision or validation, once every generation (approximately 30 years), because of changing trends in malocclusion, jaw dimension, and tooth size.[9-14]

Melgaco et al. (2007)[15] postulated an equation using the combined mesiodistal widths of both mandibular first permanent molars and incisors. According to few authors, Tanaka – Johnston's methods tended to both underestimate and overestimate the actual widths of permanent canines and premolars.[16] The applicability of these regression equations in every respective ethnic variants is definitely questionable. Hence, the present study was carried out with the objective of evaluating the applicability of Tanaka – Johnston and Melgaco's mixed

dentition analyses methods among Nalgonda population and also to derive new regression equations for this specific population.

Materials and Methods: The study was approved by the Institutional Ethical Committee, Kamineni Institute of Dental Sciences, Narketpally, Nalgonda (Dt.), Telangana State. This study was initiated after obtaining permission from the Headmasters of the respective schools, from in and around of Narketpally, Nalgonda (Dt.), and informed consent from parents of the participants.

Sample Size and Selection: A total of 200 children (100 females and 100 males), aged 12- 16 years were randomly selected who have met the selection criteria. The selection criteria included children having completely erupted permanent dentition except third molars, dentition with Class I molar relation, teeth without proximal/occlusal caries, restorations, fractures or any other abnormalities.

Procedure: Alginate impressions of both maxillary and mandibular arches for 200 selected children were made and study models were prepared (Photograph No. 1). On these 200 sets of dental casts, the greatest mesiodistal widths of permanent mandibular central incisors, lateral incisors and first molars, maxillary and mandibular canines and premolars were measured (Photograph No. 2) according to the technique proposed by Moorrees et al. (1964).[17] The digital vernier caliper was adjusted to the greatest mesio-distal diameter of the teeth, parallel to the occlusal surface and perpendicular to the long axis, with the values nearest to 0.01mm. The average value of right and left posterior segments was taken. In order to predict the mesio-distal width of unerupted canines and premolars, two non-radiographic prediction methods i.e. Tanaka- Johnston's formulae, $Y = 11 + X/2$ for the maxilla and $Y = 10.5 + X/2$ for the mandible and Melgaco's equations, $Y = 0.975X$ (males), and $Y = 0.971X$ (females) were followed. The applicability of these prediction methods was checked for this population and new regression equations were derived.

Statistical analysis: The measured dimensions from the casts and the predicted data derived from two regression equations was subjected to statistical analysis using correlation coefficients, independent 't' test, paired 't' test, and ANOVA methods. Statistical analysis was carried out using SPSS for windows (version 16.0). Descriptive statistics, including means and standard deviations were calculated for actual and predicted widths of canine and premolars of mandibular arch. To assess gender dimorphism between actual and predicted values, independent sample t-test was used.

Results: Table 1 shows the mean values of the sum of actual mesiodistal widths mandibular

permanent canines and premolars, sum of permanent mandibular incisors and the sum of mandibular incisors and first permanent molars in both males and females. When the mean sum of actual mesiodistal widths of mandibular canines & premolars, incisors and mandibular incisors & first molars were compared, no significant difference between males and females (p value - 0.062, 0.26 & 0.154).

Table 1: Mean Mesio-distal widths of mandibular canines and premolars, mandibular incisors, and sum of mandibular incisors and permanent first molars

Mesiodistal width	Sex	Mean	Std. Deviation	p- value
Mandibular canines & premolars	F	20.22467	1.156023	0.062
	M	20.56300	1.286283	
Mandibular incisors	F	22.1948	1.52167	0.268
	M	22.4332	1.38345	
Mandibular incisors & 1st permanent molars	M	43.758696	2.1186328	0.154
	F	43.265435	2.5394580	

Table 2 and 3 shows the inter-comparison of predicted values based on two regression equations in both females and males. In females, the mean actual mesiodistal widths of permanent canines and premolars was 20.22mm in mandibular arch and 20.72mm in maxillary arch. The predicted mesiodistal widths of permanent canines and premolars using TJ's method analysis was found to overestimate the actual values both in mandibular and maxillary arches (21.55mm and 22.04mm) with a statistically significant difference ($p < 0.05$). Whereas, no significant difference ($p = 0.70$) was observed between the actual mesiodistal widths and the predicted mesiodistal widths using Melgaco's regression equation. In males, the mean actual width of mandibular arch was 20.77. The predicted mesiodistal widths with Melgaco was 20.34 and Tanaka – Johnston's method was 23.80. There was no significant difference between the actual and predicted values with both Melgaco's and TJ methods in the mandibular arch. Whereas the mean actual mesiodistal width of maxillary arch was 21.35 and the predicted mesiodistal width with TJ's method was 22.17. Tanaka – Johnston's method overestimated the actual widths of both maxillary and mandibular permanent canines and premolars with a significant difference ($p<0.001$) in both males and females.

Table 4 shows the coefficient of correlation (r) and coefficient of determination ($r2$ between the actual sum of mandibular permanent canines and premolars and the sum of mandibular

incisors and the Tanaka Jhonston method and the Melgaço's method (sum of mandibular permanent incisors and permanent first molars). On comparing these values, it was evident that the methodgiven by Melgaço to use the sum of the mandibular first permanent molars and four mandibular permanent incisors (SMI) was a better predictor as compared to TJ method of using the sum of permanent mandibular incisors only.

Table 2: Inter - comparison of predicted values according to two prediction methods with actuals widths in females

Females	Actual mesiodistal widths in the mandibular arch	Melgaco	TJ	Actual mesiodistal widths in the Maxillary arch	TJ
Mean	20.22	20.18	21.55	20.72	22.04
SD	1.15	1.27	1.00	1.15	0.98
SE	0.12	0.13	0.10	0.12	0.10
p		0.70	**0.000***		**0.000***

Table 3: Inter - comparison of two prediction methods with actual widths in males

Males	Actual mesiodistal widths in the mandibular arch	Melgaco	TJ	Actual mesiodistal widths in the Maxillary arch	TJ
Mean	20.77	20.34	23.80	21.35	22.17
SD	2.37	1.02	20.67	2.31	0.74
SE	0.24	0.10	2.13	0.23	0.07
p		0.10	0.16		**0.001***

Table 4: Coefficient of correlation (r), regression constants (a, b), and coefficient of determination (r2) for various tooth groups in different groups of subjects

		r	A	B	r^2
	Male	0.560	11.248	0.411	0.313
	Female	0.640	9.799	0.469	0.409
Sum of Mandibular incisors	**Male + Female**	0.292	14.872	0.247	0.086

Prediction equations using gender-specific regression analysis (Tables 5, 6, 7 &8):

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Gender Specific regression analysis was derived for calculation of the sum of the canine and premolars based on the sum of mandibular incisors in Maxillary arch for females. The proposed equation was:

Maxillary arch – Y = 13.13 + 0.334 X

Coefficients[a]

Table 5: Gender specific regression analysis for calculation of sum of canine and premolars based on sum of mandibular incisors in Maxillary arch among females

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	13.319	1.362		9.780	.000
	Si	.334	.061	.489	5.464	.000

a. Dependent Variable: Maxillary arch

Gender Specific regression analysis was derived for calculation of the sum of the canine and premolars based on the sum of mandibular incisors in Mandibular arch for males. The proposedequation was:

Mandibular arch– Y = 9.799 + 0.469 X

Coefficients[a]

Table 6: Gender specific regression analysis for calculation of sum of canine and premolars based on sum of mandibular incisors in Mandibular arch among females

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	9.799	1.286		7.618	.000
	Si	.469	.058	.640	8.113	.000

a. Dependent Variable: Mandibular arch

Gender Specific regression analysis was derived for calculation of the sum of the canine and

premolars based on the sum of mandibular incisors in Maxillary arch for males. The proposed equation was:

Maxillary arch – Y = 12.44 + 0.386 X

Table 7: Gender specific regression analysis for calculation of sum of canine and premolars based on sum of mandibular incisors in Maxillary arch among males

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.445	1.467		8.485	.000
	si	.386	.065	.519	5.910	.000

a. Dependent Variable: Maxillary arch

Gender Specific regression analysis was derived for calculation of the sum of the canine and premolars based on the sum of mandibular incisors in Mandibular arch for males. The proposedequation was:

Mandibular arch – Y = 11.24 + 0.41 X

Table 8: Gender specific regression analysis for calculation of sum of canine and premolars based on sum of mandibular incisors in Mandibular arch among males

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	11.248	1.401		8.026	.000
	si	.411	.062	.560	6.587	.000

a. Dependent Variable: Mandibular arch

Discussion: As paediatric dentists deal with children from infancy to adulthood through their adolescence, they often have the chance to view all phases of dentition during development of occlusion. During mixed dentition period, either due to premature loss of primary teeth or normal physiological exfoliation of deciduous teeth and delayed eruption of permanent teeth, many tooth size arch length discrepancies take place in the oral cavity. The preliminary step of paediatric dentist is to forecast the space availability or deficiency for the unerupted permanent canines and premolars using MDSA, which would guide in early intervention of various malocclusions, if any. A plethora of articles published in the literature say that tooth dimensions vary with race, ethnicity and genetic background, hence race specific predictive regression equations are required for different parts of the world in order to analyse mixed dentition aptly foran accurate diagnosis and treatment planning.

In 1897, Black proposed tables based on average widths to predict the mesiodistal widths of unerupted teeth.[2] In 1946, Carey reported the presence of a significant linear association between the sum of the lower permanent incisors and sum of the unerupted mandibular permanent canines and premolars.[3] Later, Nance (1947), first suggested the use of periapical radiographs for measurement of the width of unerupted teeth and observed that it tended to overestimate the tooth widths. The Moyer's probability tables were developed in 1973 based on odontometric data of American White subjects of North European descent and observed that it underestimated the actual widths in non-caucasians.[4] However, the most popularized mixed dentition analyses methods to predict the width of unerupted canines and premolars are Moyers probability tables and Tanaka and Johnston's regression equation method. Gupta DS (2012)[5] presented a new system using the mesiodistal widths of mandibular first permanent molars. Several combinations of teeth have been taken to predict the width of canines and premolars by various authors.[18,19,21-23] It was reported that sum of the mesiodistal widths of permanent mandibular incisors is not the best predictor for estimating the mesiodistal widths of canines premolars (Nourallah et al., 2002[17]; Legovic et al, 2003[24]; Melgaco et al, 2007[15]). Melgaco et al.2007 reported that the total widths of permanent mandibular first molar and incisors (TWFMI) had a high prediction correlation *(r)* and determination *(r^2)* value.[15] In addition to racial differences of the tooth size, sexual dimorphism also has been reported[16] but in contrast, no statistically significant difference in mesiodistal widths of teeth between males and females was found in this study. The findings of the present study was in accordance with few other authors.[25-27]

In the present study, a statically significant difference between the actual and predicted

mesiodistal widths was observed with TJ's method in both maxillary and mandibular arches in females and maxillary arch in males but with no significant variation in mandibular arch among males group. These findings were in accordance with few other studies. Paula et al. (1995)[28] and Melgaco et al. (2006)[29] found statistically significant difference with Tanaka and Johnston's equation. Mengal and Afzal (2004)[30] found that actual widths of the mandibular canine and premolars showed a significant difference in size ($p < 0.000$) from the widths predicted by the Tanaka and Johnston's method. Bhatnagar A et al. (2018)[31] reported that Tanaka– Johnston, Bernabe–Flores-Mir and Ling–Wong regression equations signicantly overestimate the mesiodistal widths of permanent canine and premolars of school going children's of Moradabad city, North Uttar Pradesh. According to Sharma R V et al. (2021)[32], The Tanaka – Jhonstons Mixed dentition analysis method which was used for Northern European ancestry was not reliable for an Indian population. Thus, the data illustrated that Tanaka and Johnston method overestimated the mesiodistal diameters of unerupted canines and premolars for this population. Hence new regression equations were formulated for this group of population.

Although it has a tendency to overestimation, the Melgaco method of model analysis seemed to be consistent and applicable to the studied population. These results can be credited to the high correlation (r) and determination (r^2) coefficients in the original study ($r = 0.81$and $r^2 = 0.656$, for both sexes) and confirmed by Rasool et al. (2008)[33] ($r = 0.673$ and $r^2 = 0.452$ for both sexes), and concluded that sums of the mandibular permanent first molars and incisors are good predictors for the sums of the mesiodistal widths of the permanent canines and premolars. The correlation coefficients calculated in the present study (for maxilla in males, r is 0.64; for mandible in males, r is 0.55; for maxilla in females, r is 0.68 and for mandible in females, r is 0.64 showed a strong correlation for the mandibular buccal segments and also strong correlation for the maxillary buccal segments. Similar conclusions were obtained by Jaroontham and Godfrey (2000)[34] and Tahere et al. (2007).[35]

In the current study, Melgaco's equation predicted very close to the actual values of canine and premolars in both the genders, thus can be applied for mixed dentition analysis in this population. A moderate correlation was found in the present study between TCPW and TWFMI for the whole sample ($r = 0.641$), which is comparable with the findings of Bernabé and Flores-Mir (2005)[19] and Melgaço *et al.* (2007)[15]. van der Merwe et al. (1991)[35] reported, in their population, that the sum of the four lower incisors was the best predictor for estimating the mesiodistal widths of the canines and premolars. On the other hand, Bernabé and Flores-

Mir (2005) and Nourallah *et al.* (2002) concluded that the combined widths of the four mandibular permanent incisors were not a good predictor of the mesiodistal widths of the unerupted mandibular canines and premolars. The results of present study are in reasonable agreement with their findings. However, Melgaço *et al.* (2007), in a similar study in a Brazilian population, found a higher correlation (r = 0.81) when compared with the present findings. This difference may be due to the influence of genetics when compared with the Brazilian study.

Conclusion: When Melgaco's regression equation was applied for this group of population in order to predict the mesio-distal widths of unerupted canines and premolars, no significant difference was observed between the actual widths and predicted widths. Sum of the mesiodistal widths of mandibular first molar and incisors was found to be good predictor of widths of unerupted mandibular canines and premolars and seemed to be consistent and applicable to the studied population. Tanaka – Johnston's method overestimated the actual widths of canines and premolars in this group of population. Hence, new regressions equations were formulated. Validating studies (based on similar samples) must be conducted to confirm the applicability and precision of the new regression equations proposed.

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