18387-Akbar-APPLICABILITY OF TANAKA AND JOHNSTON PREDICTION EQUATIONS

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APPLICABILITY OF TANAKA AND JOHNSTON PREDICTION EQUATIONS IN CONTEMPORARY POPULATION OF PAKISTANI PASHTUNS

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ABSTRACT:

Objective: To determine the accuracy of Tanaka and johnston prediction equations when applied to a sample of Pashtunpopulation of Pakistan.

Methods: Odontometric data from casts of 180 subjects (90 males and 90 females, ages 13-19 years) of Pashtun origin was collected using digital callipers and subjected to statistical and linear regression analysis.

Results: Statisticallysignificant differences were noted between male and female tooth sizes. Tanaka and johnston equations significantly overestimated the sizes of canines and premolars when applied to ethnic Pashtun population. Regression equations were developed for use in local population.

Conclusion: Tanaka and johnston equations developed for North American population (at 75th percentile) should be used with caution for mixed dentition analyses in local Pashtunpopulationas it overestimates tooth sizes in males and females. Regression equations developed in this study can be used for diagnostic planning in local Pashtun children.

Key words: Tanaka and johnston, regression equations, mixed dentition analyses.

INTRODUCTION

Prediction of mesiodistal widths of unerupted canines and premolars during mixed dentition is an interesting aspect orthodontic diagnosis and treatment. Researchers have developed various methods for estimating the crown widths of these unerupted teeth which include the use of prediction equations and probability tables, developed by Tanaka and Johnston[1] and Moyers[2], radiographic techniques as suggested by Staley et al[3] and Huckaba et al[4]and a combination of these techniques as used by HixonOldfather[5] and Bishara et al.[6]

Since the general tendency is to use the simplest approach possible, Tanaka and johnston[1]prediction equations became widely used for its ease of use, effectiveness and lack of need for any expensive equipment or exposure to radiation. However since these prediction equations were developed from odontometric data derived from population of North European descent, the accuracy of these equations is questionable when applied to local ethnic population.[7]

Review of literature shows that researchersinEgypt,[6]Turkey,[7]America,[8]Peru,[9] Saudi Arabia,[10] Jordan,[11]Italy,[12] Syria,[13] India,[14] Hong Kong,[15] Thailand,[16] Nigeria[17] and Morocco[18] have reported significant differences between actual and predicted mesiodistal widths of canine premolars segments when Tanaka and Johnston[1]regressions are applied to other populations and ethnic groups (Table I). Studies on Pakistani population carried out by Mengal and Afzal[19] and Bherwani et al[20] have reported significant differences between actual and predicted mesiodistal widths of canine premolar segments whereas a study by Sarwat et al[21] reported non-significant differences when Tanaka and Johnston[1] prediction equations were applied to local population groups.

However these studies[19-21] did not ethnically profile the subjects in their samples which can lead to errors when applying their values to different ethnic groups in Pakistan.[22]Therefore this study was carried out in a population sample of Pashtuns (who constitute an indigenous ethnic group settled in Northwest Pakistan and Eastern Afghanistan) to find out; 1) the applicability of Tanaka and Johnston[1]equations in Pashtuns, 2) to determine the accuracy of regression equations developed by Bherwani et al for Pakistani population in ethnic Pashtungroup and 3) to develop regression equations for Pashtun population if necessary.

METHODS

Data Collection

Dental casts of 180 subjects (90 females and 90 males, average age 15.54 years) that met the inclusion criteria were collected at Sardar Begum Dental Hospital, Gandhara University Peshawar. The subjects included were those with an age range 13-19 years, who had full set of permanent teeth from first molar to first molar in both arches and were Pustun residents of Khyber Pukhtunkhwa province with at least past two generations of Pustun ancestry whereas patients with interproximal caries, restorations, hypoplastic or worn down teeth, syndromic patients and those with severe crowding which would complicate tooth size measurements were excluded. Patients with damaged cast records and previous history of Orthodontics were also excluded.

Measurement Method

Digital vernier calliper (Mitotoyo, Kawasaki, Japan) calibrated to the nearest of 0.01 mm was used to measure the mesiodistal widths lower incisors, maxillary and mandibular canine and premolars on dental casts according to the method suggested by Moores and Reed.[23] The measurements for right and left sides were averaged to obtain a single value for canine premolar segments

Reliability of measurements

Good intraexaminer reliability (r>0.95) was found by a method suggested by Lundstrom[24] where the same investigator (AAK)measures all the cast and then re-measures a few(30 in this study) randomly selectedcasts after a period 2 weeks.

Benchmark of clinical significance

Lee Chen et al[8] and Bishara et al[25] have suggested that the difference between actual and predicted widths of canine premolar segments should be $\geq$ 1mm per quadrant to be clinically significant.

STATISTICAL ANALYSIS

Descriptive statistics including means, standards deviations and ranges were calculated for age, individual teeth (lower incisors, canines and premolars) and tooth segments (lower incisors and canine premolar segments). Student t test was used to analyze the difference between right and left canine premolar segments of upper and lower arches in both males and females. Independent sample t test was used to determine difference in tooth sizes between males and females. Repeated measures ANOVA was used to compare the actual tooth sizes and tooth sizes predicted by Tanaka and Johnston[1] and Bherwani's[20] regression equations. Regression equations were derived alongwith correlation coefficients (r) and coefficients of determination (r^2) to analyze the relationships between lower incisors and canine premolar segments in both arches.Data was analysed using SPSS software version 20 for Windows.

RESULTS

Data was analysed for 90 male and 90 female subjects with a mean age of 15.7 years (SD, 1.7) and 15.4 years (SD, 1.5), respectively. Descriptive statistics for individual teeth and groups of teeth are summarized in Table II. Generally larger tooth sizes were noted in males than in females. Also the mesiodistal tooth width of canine premolar segment was slightly larger in maxilla that in mandible for both male and female groups.

Statistically insignificant differences, except for upper arch in males, were found between right and left canine premolar segments of males and females within the corresponding arches as shown in Table III. Statistically significant difference was noted for combined tooth widths only for upper arch in males (mean =0.08mm, p=0.027). However, this difference was below the level of clinical significance of 0.25mm as suggested by Ballard,[26] hence it could be ignored and the values of right and left sides were averaged in this study to obtain a single value for canine premolar segments.

The values of tooth sizes obtained from male and female samples were computed to evaluate for sexual dimorphism. Statistically significant differences were noted for individual teeth and for groups of teeth with males showing larger tooth sizes than females (Table IV). Individually the greatest difference was noted for lower canines and least for lower central incisors. In groups of teeth, differences recorded were least forlower incisors segment and greatest for lower canine-premolar segment.

Actual mesiodistal widths of canine premolar segments derived in this study were compared to those predicted by regression equations derived by Tanaka and Johnston[1] for North American population and by Bherwani et al[20] for Pakistani population (Table V). Statistically significant overestimations of tooth sizes was observed when applying Tanaka and Johnston[1]equations to both arches of male and female Pashtuns but the differences were clinically relevant in females. However, except for upper arch in males, Bherwani's[20] prediction equations significantly underestimated from the actual tooth sizes in both males and females, with clinically significant differences for lower arches of both genders.

Regression equations represented by $y=a+b(x)$were derived from the data (Table VI). Here $y$denotes the mesiodistal widths of unerupted canine and premolars for one segment, a is slope of the curve, b is the y-intercept and x is mesiodistal width of lower incisors in millimetres. The values for coefficient of correlation (r) ranged from 0.59 to 0.73 and the coefficient of determination (r^2) ranged from 0.36 to 0.52.

DISCUSSION

Various investigators[13, 16, 25, 27, 28] have confirmed differences in tooth sizes based on racial and ethnic backgrounds.[22] Frankel and Benz[29] have suggested that the similarity in tooth sizes in a particular race or ethnicity may be due to similar gene pool as compared to other groups. The hereditary differences serve a basis of inaccuracies when prediction equations derived from odontometric data of a certain race/ethnicity are applied to another group.[30]

In our study it was observed that both prediction equations developed by Tanaka and Johnston[1] and Bherwani et al[20] did not completely satisfy the condition of clinical accuracy for both genders or for both arches. Bherwani et al[20] derived prediction equations from a population sample based on nationality rather than on ethnicity, which could explain the differences reported in this study. Any approximation of actual and predicted values of canine-premolar segments observed, such as in upper arch of males, could be attributed to chance (Table V).

Regression equations were derived from the data in our study at the 75th percentile. Experienced clinicians may prefer the 50th percentile to equalize the margin of error between underestimation and overestimation but Moyers[2] suggested a slight overestimation of values as relative spacing can be easily managed by orthodontic therapy as compared to crowding.

The coefficient of correlation (r) shows the strength of relation between the lower incisor segment and the canine-premolar segments.The values of r in our study were generally above 0.5 for both arches in males and females which means that the lower incisors segment can be used to construct prediction equations for canine-premolar segments with relativereliability (Table 6). The coefficient of determination (r^2) shows the accuracy of fit of the regression equation. The r^2values derived in this study were in the moderate range and comparable to other studies, given in Table 6. The moderate to low values of r^2 usually observed for simple regressions is the reason for some clinicians to prefer the use of complex multiple regressions which gives slightly higher values for r^2.[31-34] However, the clinical advantage of comparatively higher r^2valuesstill needs to be scientifically confirmed.

Since sexual dimorphism for tooth sizes was reported in this study, separate regression equations were derived for males and females for accurate prediction. However for ease of use and memorization, combined prediction equations were also developed by approximation of male and female tooth sizes.

CONCLUSION

1. Tanaka and Johnston[1] regressions did not accurately predict the mesio-distal widths of canine premolar segments in ethnic Pashtuns.
2. Regression equations based on nationality may not be reliable for use in a specific ethnic group.
3. Significant sexual dimorphism in tooth sizes exists for Pashtun population.
4. The regression equations derived for prediction of unerupted canine-premolar segments in Pashtuns are given as;
    a. For combined males and females,
        i. Upper Arch, $y=8.62+0.65(x)$
        ii. Lower Arch, $y=6.24+0.7(x)$
    b. For males only,
        i. Upper Arch, $y=9.82+0.61(x)$
        ii. Lower Arch, $y=9.57+0.62(x)$
    c. For Females Only,
        i. Upper Arch, $y=10.1+0.59(x)$
        ii. Lower Arch, $y=5.35+0.73(x)$

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Table I

COMPARISON OF REGRESSION CONSTANTS IN DIFFERENT STUDIES

				Constants			
Study	Arch		r	a	b	SEE	r^2
Frankel & Benz[29]	Mx		0.62	11.93	0.44		0.38
	Md		0.70	9.93	0.52		0.49
Al Khadra[10]	Mx		0.65	7.20	0.63		0.42
	Md			8.60	0.55		0.49
Jaroontham& Godfrey[16]	Mx		0.60	11.87	0.47	0.84	0.36
	Md		0.64	10.3	0.50	0.82	0.41
Phillips et al[14]	Mx	M	0.66	7.15	0.67	0.81	0.43
		F	0.65	7.44	0.65	0.72	0.43
	Md	M	0.68	5.55	0.71	0.80	0.46
		F	0.67	6.15	0.67	0.71	0.44
Al Bitar et al[11]	Mx		0.60	10.94	0.46	0.84	0.36
	Md		0.66	8.43	0.55	0.86	0.44
Tanaka & Johnston[1]	Mx		0.63	10.41	0.51	0.86	0.40
	Md		0.65	9.18	0.54	0.85	0.42
Bherwani et al[20]	Mx		0.59	10.52	0.48	0.82	0.35
	Md		0.65	8.56	0.54	0.79	0.42

Mx, maxilla; Md, mandible; M, male; F, female; SEE, standard error of estimate.

TABLE II

DESCRIPTIVE STATISTICS FOR LI AND CPM

		Maxillary Arch			Mandibular Arch		
Tooth	Sex	Mean (mm)	SD (mm)	SEM (mm)	Mean (mm)	SD (mm)	SEM (mm)
LCI	Both				5.63	0.36	0.02
	F				5.54	0.34	0.03
	M				5.72	0.37	0.03
LLI	Both				6.2	0.39	0.03
	F				6.09	0.38	0.04
	M				6.31	0.39	0.04
LI	Both				23.67	1.41	0.11
	F				23.26	1.31	0.13
	M				24.08	1.39	0.14
C	Both	7.92	0.51	0.04	6.97	0.47	0.03
	F	7.69	0.43	0.04	6.72	0.41	0.04
	M	8.15	0.48	0.05	7.22	0.41	0.05
PM1	Both	7.24	0.46	0.03	7.3	0.52	0.04
	F	8.05	0.43	0.04	7.15	0.52	0.05
	M	7.39	0.45	0.05	7.44	0.48	0.05
PM2	Both	6.95	0.47	0.03	7.31	0.48	0.04
	F	6.84	0.43	0.04	7.19	0.47	0.05
	M	7.07	0.49	0.05	7.43	0.46	0.05
CPM	Both	22.12	1.24	0.09	21.58	1.30	0.09
	F	21.64	1.09	0.11	21.08	1.22	0.12
	M	22.6	1.21	0.12	22.09	1.17	0.12

LCI, lower central incisor; LLI, lower lateral incisor; LI, lower incisors; C, canine; PM1, first premolar; PM2, second premolar; CPM, canine and premolars; M, male; F, female; SEM, standard error of mean.

TABLE III

RIGHT AND LEFT TOOTH SIZE DIFFERENCES FOR CPM SEGMENTS

Sex	Tooth segment	Mean difference (mm)	SD	t	df	P value
M+F (n=180)	Upper CPM	0.159	0.66	3.241	179	0.001*
	Lower CPM	-0.061	0.67	-1.22	179	0.223
M (n=90)	Upper CPM	0.08	0.34	2.256	89	0.027*
	Lower CPM	0.001	0.54	0.019	89	0.985
F (n=90)	Upper CPM	0.164	0.80	1.943	89	0.06
	Lower CPM	-0.122	0.76	-1.514	89	0.134

CPM, canine and premolars; M, male; F, female; SD, standard deviation.
*$p<0.05$

TABLE IV

GENDER DIMORPHISM FOR TOOTH SIZES

Tooth Segment	Sex	Mean (mm)	SD	Mean difference	P value
UC	M (n=90)	8.14	0.47	-0.451	0.000*
	F (n=90)	7.69	0.44		
UPM1	M (n=90)	7.38	0.45	-0.290	0.000*
	F (n=90)	7.09	0.44		
UPM2	M (n=90)	7.06	0.49	-0.223	0.002*
	F (n=90)	6.84	0.43		
LC	M (n=90)	7.22	0.41	-0.493	0.000*
	F (n=90)	6.73	0.41		
LPM1	M (n=90)	7.44	0.49	-0.286	0.000*
	F (n=90)	7.16	0.52		
LPM2	M (n=90)	7.43	0.47	-0.233	0.001*
	F (n=90)	7.19	0.47		
LCI	M (n=90)	5.72	0.37	-0.179	0.001*
	F (n=90)	5.54	0.34		
LLI	M (n=90)	6.31	0.39	-0.231	0.000*
	F (n=90)	6.09	0.38		
Upper CPM	M (n=90)	22.60	1.21	-0.965	0.000*
	F (n=90)	21.64	1.09		
Lower CPM	M (n=90)	22.09	1.17	-1.013	0.000*
	F (n=90)	21.08	1.23		
LI	M (n=90)	24.08	1.39	-0.821	0.000*
	F (n=90)	23.26	1.32		

LCI, lower central incisor; LLI, lower lateral incisor; LI, lower incisors; UC, upper canine; UPM1, upper first premolar; UPM2, upper second premolar; LC, lower canine; LPM1, lower first premolar; LPM2, lower second premolar; CPM, canine and premolars; M, male; F, female; SD, standard deviation

*$p<0.05$

TABLE V

DIFFERENCES BETWEEN ACTUAL AND PREDICTED TOOTH SIZES

Tooth Segment	Sex	Actual MD widths (mm)	MD widths as predicted by Johnston & Tanka Regression (mm)	Mean Difference from actual (mm)	P Value	MD widths as predicted by Bherwani'sR egression (mm)	Mean Difference from actual (mm)	P Value
UpperCP M	M+F	22.12±1.24	22.83±0.71	-0.72±0.96	0.000*	21.88±0.67	0.24±0.96	0.001*
	M	22.60±1.21	23.04+0.69	-0.44+0.96	0.000*	22.08±0.67	0.52±0.96	0.000*
	F	21.64±1.09	22.63+0.66	-0.99+0.87	0.000*	21.69±0.63	-0.05±0.87	0.598
Lower CPM	M+F	21.58±1.30	22.33±0.70	-0.75±094	0.000*	20.21±0.70	1.37±0.59	0.000*
	M	22.09±1.17	22.54±0.70	-0.44±0.93	0.000*	20.49+0.63	1.60±0.54	0.000*
	F	21.08±1.22	22.13±0.66	-1.05±0.87	0.000*	19.94+0.66	1.13±0.56	0.000*

CPM, canine and premolars; MD, mesiodistal; M, male; F, female
*p<0.05

TABLE VI

REGRESSION PARAMETERS FOR PREDICTION OF CANINE-PREMOLARS SEGMENTS IN ETHNIC PASHTUNS

			Constants			
Sex	Arch	r	a	b	SEE	r^2
Combined	Mx	0.65	8.62	0.65	0.95	0.42
	Md	0.70	6.24	0.70	0.93	0.49
Males	Mx	0.61	9.82	0.61	0.97	0.37
	Md	0.62	9.57	0.62	0.93	0.38
Females	Mx	0.59	10.1	0.59	0.88	0.35
	Md	0.73	5.35	0.73	0.85	0.53

Mx, maxilla; Md, mandible; SEE, standard error of estimate

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