Original Article

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AN EVALUATION OF THE VALIDITY OF MOYER'S ANALYSIS AND ELABORATION OF PREDICTION TABLES FOR BANGALORE URBAN SCHOOL CHILDREN

Umapathy T, * Praveen P, ** Ananthraj A, *** Ashwini CP

* Reader, Department of Pedodontics and Preventive Dentistry, Rajarajeswari Dental College and Hospital, Bengaluru, Karnataka, India
** Professor, Department of Pedodontics and Preventive Dentistry, DA Pandu Memorial R V Dental College and Hospital, Bengaluru, Karnataka India
*** Professor &Head, Department of Pedodontics and Preventive Dentistry, DA Pandu Memorial R V Dental College and Hospital, Bengaluru, Karnataka India
*** BDS, Consultant Dental Surgeon, Bengaluru, Karnataka India

ABSTRACT

Introduction: The Moyer's mixed dentition analysis forms an essential part of diagnostic procedures to determine adequacy of the space available for the erupting permanent teeth. However, its reliability among other racial groups has been questioned. **Objectives**: The objectives of this study were to test the reliability of Moyer's method for Bangalore population and to produce odontometric data for Bangalore population sample for predicting the mesio-distal diameters of the unerrupted permanent successors. **Methodology**: Data was collected from study models of 400 randomly selected Bangalore subjects aged 13 to 16 years with fully erupted, intact dentitions and no significant malocclusion. The meso-distal widths of the incisors, canines& premolars of both arches were measured. This data was then utilized to predict the mesio-distal widths of canines and premolars and further compared with Moyer's table. **Conclusion**: It was found that 50% is more applicable to boys and 75% to girls. The canine premolar segment in both arches are statistically larger in men than in women ($p<0.05$). New probability tables for Bangalore subjects were formulated. The accuracy of this table needs to be evaluated further in a large sample of the local population and various other ethnic groups in Bangalore.

KEYWORDS: Mixed dentition analysis; prediction equations; probability tables

INTRODUCTION

Malocclusion which is in dormant condition in the deciduous or mixed dentition period usually surfaces after the eruption of permanent successors. A majority of children will be benefited if such developing malocclusion can be diagnosed and treated early. One of the orthodontic problems observed in the mixed dentition phase is related to arch length and tooth size discrepancy. In order to identify such space discrepancies different methods of mixed dentition space analyses have been introduced. These analyses predict the mesio-distal width of the unerrupted premolars and canines and the amount of space available in the dental arch for the alignment of the succedaneous teeth. Space analysis in the mixed dentition is an important aspect of orthodontic diagnosis and treatment planning. The purpose of a mixed dentition analysis is to evaluate the amount of space available in the arch for the succeeding permanent teeth and occlusal adjustment.[1] Different methods of predicting the sizes of permanent canines and premolars have been published.[2] Early attempts of estimating tooth sizes by G.V. Black and others were based on tables of average mesio-distal width.[3-5] Other methods of prediction were based on estimating the size of permanent teeth on radiographs alone or in combination with crown diameters measured on dental casts.[5-8] One method which is widely used correlates the mesio-distal crown diameters of erupted mandibular permanent incisors as the predictor for the size of unerrupted canines and premolars.[9] Among the different methods available Moyer's mixed dentition analysis is probably the most widely used. Moyer's

Table 1: Descriptive statistics for UCPM, LCPM, and LI

Groups of teeth	Male		Female	
	Mean	SD	Mean	SD
Lower Incisors	23.87	2.15	23.51	1.43
LCPM	21.36	0.63	21.18	0.95
UCPM	21.89	0.89	21.82	0.90

Table 2: Shows 't' test for independent samples

Independent Samples Test

	t-test for Equality of Means		
	t	df	sig
Comb. M-D width of lower incisors	1.922	346.394	.055
mean lower	2.291	346.571	.023
mean upper	.777	397.958	.438

Table 3: Regression parameter for prediction of M-D widths

Variables	X	SEX	N	Constant a	P (a)	Constant b	P(b)	r^2	SEE	r
UCPM	LII	M	200	16.904	<0.01	0.209	<0.01	0.254	0.773	0.504
UCPM	LII	F	200	15.627	<0.01	0.263	<0.01	0.175	0.821	0.419
LCPM	LII	M	200	17.204	<0.01	0.174	<0.01	0.352	0.511	0.593
LCPM	LII	F	200	13.431	<0.01	0.330	<0.01	0.247	0.827	0.497

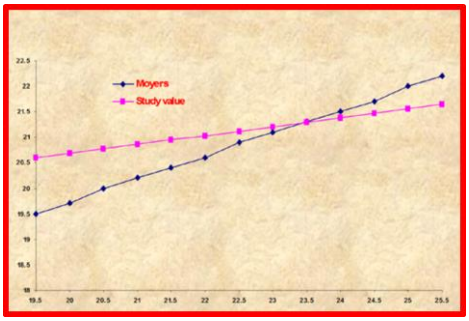

Fig. 1: Predicted values of unerrupted mandibular canines and premolar

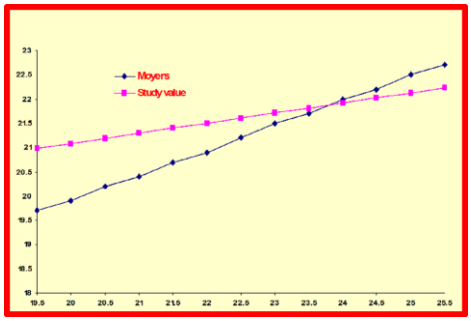

Fig. 2: Predicted values of unerrupted maxillary canines and premolar

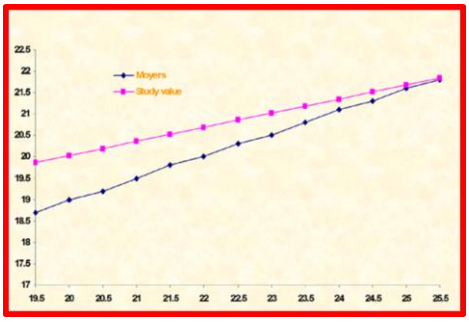

Fig. 3: Predicted values of unerrupted mandibular canines and premolar

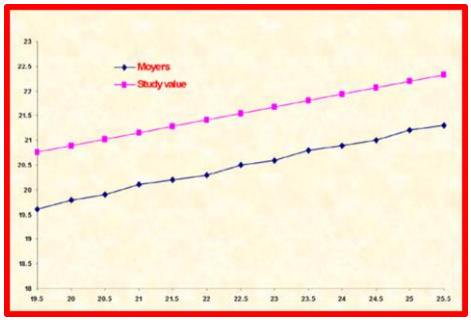

Fig. 4: Predicted values of unerrupted maxillary canines and premolar

probability tables were developed from studies conducted on Caucasian population.[10-14] This is a correlative method that uses the combined mesiodistal widths of the erupted mandibular permanent incisors to predict the mesiodistal widths of the unerrupted canines and premolars with the use of a prediction chart that has been prepared. Moyer's has also suggested that the

seventy fifth percentile readings on the prediction chart be taken as the most applicable value. However, the applicability of these tables to other ethnic groups has been studied and found wanting.[15,16] It has also been well established in the literature that mesio-distal widths of teeth vary considerably between different racial groups.[17-19] Sexual dimorphism has also been confirmed in several studies.[20,21] Only a few studies have been conducted to test the specific applicability of Moyer's tables on South Indian population. Therefore, the objectives of this study were:

1) To test the reliability of Moyer's mixed dentition analysis in Bangalore population,
2) To produce odontometric data for Bangalore population sample; so that it can be routinely used to estimate the mesio-distal widths of the unerrupted permanent successors.

MATERIALS AND METHODS

Materials

1) Mouth mirror
2) Explorer
3) Probe
4) Impression trays
5) Rubber bowl
6) Mixing spatula
7) Water
8) Irreversible hydrocolloid impression material (Alginate)
9) Dental stone
10) Vernier gauge calipers.

Methodology

This study was done among 400 school children (200 boys and 200 girls) of Bangalore in the age group of 13-16yrs whose mother tongue was Kannada. Bangalore was divided into north and south, from which two schools were randomly selected from each zone. From these schools, 200 children from north Bangalore and 200 children from south Bangalore were selected by stratified random sampling.

The criteria for selection were as follows;

1) The children should be in the age group of 13-16 yrs.
2) All the permanent teeth should be present in each arch and fully erupted (with the exception of third molars).
3) All the permanent teeth should be caries free.
4) No more than minor malocclusion or mild crowding or spacing should be present.
5) Children with congenital craniofacial anomalies or previous history of orthodontics were excluded.
6) Children with proximal caries, restorations or significant attrition were excluded.

Impressions of maxillary and mandibular arches were made of the selected children with alginate impression material. Study models were then prepared carefully using dental stone plaster. Measurements of the mesio-distal widths of mandibular incisors, maxillary and mandibular canines and premolars were made with the help of Vernier gauge calipers calibrated to 0.01 of a millimeter. All the measurements were done by a single investigator after carefully marking the maximum mesio-distal width on the teeth to be measured. The sum of the mesiodistal measurements of the following groups of teeth was pooled and the means were calculated: (1) the four mandibular incisors, (2) the mandibular canines and premolars, (3) the maxillary canines and premolars per quadrant. These data were then used to develop regression equations that could be used clinically for the prediction of tooth sizes in local ethnic population.

The following abbreviations are used in this study:

UCPM- Combined mesio-distal crown diameters of upper permanent canine and first and second premolars on one side of the arch.

LCPM- Combined mesio-distal crown diameters of lower permanent canine and first and second premolars on one side of the arch.

LII- Combined mesio-distal crown diameters of the four lower permanent incisors.

Y=a+b(x)- Simple linear regression equation, where 'Y' is the dependent variable UCPM or LCPM as specified, 'x' is the independent variable LII, 'a' is the co-efficient for the 'Y'-intercept of the regression line, and 'b' is the co-efficient for the slope of the regression line

These linear square regression equations were calculated as follows:

$$Y=a+b\,(X)$$

Where Y equals the predicted mesiodistal size of the canine and premolars (maxillary or mandibular) in one quadrant in millimeters and 'x' equals the measured mesiodistal width of the four permanent mandibular incisors in millimeters. a+b equals the constants to be derived (a is the y-intercept and b the slope of the

Table 4: Prediction table for Bangalore Boys (mm)

Sum of L I	LCPM	UCPM
19	20.51	20.88
19.5	20.60	20.98
20	20.68	21.08
20.5	20.77	21.19
21	20.86	21.29
21.5	20.95	21.40
22	21.03	21.50
22.5	21.12	21.61
23	21.21	21.71
23.5	21.29	21.82
24	21.38	21.92
24.5	21.47	22.02
25	21.55	22.13
25.5	21.64	22.23
26	21.73	22.34
26.5	21.82	22.44
27	21.90	22.55
27.5	21.99	22.65
28	22.08	22.76
28.5	22.16	22.86
29	22.25	22.97

regressions of the line. Probability tables for Bangalore children were constructed. Statistical analysis was performed with statistical software.

STATISTICAL ANALYSIS

The data collected is subjected to statistical analysis using SPSS for windows statistical computer package (Version 7.5.1). Microsoft Excel is used for generating the tables and graphs.

RESULT

The results of the present study are presented as follows:

Table 1: Descriptive statistics for summation of upper canine and premolars diameters (UCPM), summations of lower canine and premolars diameters (LCPM), and summation of lower incisors mesiodistal diameters (LI) are presented in Table I for the sexes, males and females separately. The mean value of lower incisor for female sample was 23.51±1.43, for UCPM was 21.82±0.90, and for LCPM was 21.18± 0.95. The mean value of lower incisor for male sample was 23.87± 2.15, for UCPM was 21.89±0.89 and for LCPM was 21.36±0.63. The canine premolar segment in both arches are statistically larger in men than in women ($p<0.05$). **Table 2:** There were significant differences(all $P<0.05$ except for means of upper) for t-tests comparing the means of males with females for summations of mandibular incisors and maxillary and mandibular canines and premolars width, males having the larger values. **Table 3:** Correlation co-efficient and equations of prediction were derived from the data collected. Table II shows correlation coefficients (r) between LI and canines and premolars for males and females, the regressions values of 'a' and 'b' in the standard linear regression equation (Y=a+b.x), the SEE, and the r square of the maxillary and mandibular regression equation. The correlation between the mesiodistal width of erupted mandibular incisors and mesiodistal with of erupted canines and premolars showed a fair correlation. The correlation coefficients between the independent variable (LI) and the dependent variables were 0.50 (for UCPM) and 0.59 (for LCPM) in males and 0.41 and 0.49, respectively, in females. The correlation coefficients ranged from 0.41 to 0.59 with the coefficients higher in men. In order to

Table 5: Prediction table for Bangalore Girls (mm)

Sum of L I	LCPM	UCPM
19	19.70	20.62
19.5	19.87	20.76
20	20.03	20.89
20.5	20.20	21.02
21	20.36	21.15
21.5	20.53	21.28
22	20.69	21.41
22.5	20.86	21.54
23	21.02	21.68
23.5	21.19	21.81
24	21.35	21.94
24.5	21.52	22.07
25	21.68	22.20
25.5	21.85	22.33
26	22.01	22.47
26.5	22.18	22.60
27	22.34	22.73
27.5	22.51	22.86
28	22.67	22.99
28.5	22.84	23.12
29	23	23.25

asses the effect of sex on the regressions, the combined diameters of the canines and premolars were first regressed on combined lower incisor diameters and sex using a general linear model procedure. The p- value associated with sex was found to be less than 0.01. Hence simple linear regressions were performed with the sexes separated. All four-regression models were statistically significant. The coefficients of determination (r^2) explained the portion of variability of the dependent variable that could be explained by the variability of the independent variable. The r^2 values ranged from 17% in females to 35%, with the figures in males consistently better than those for the females. The standard errors of estimate ranged from 0.511mm to 0.827 with the errors smaller in males. The values of coefficients 'b' ranged from 0.174 to 0.330 and significant at $p<0.01$. The values of co-efficient 'a' ranged from 13.431 to 17.204 and significant at $p<0.01$. Linear regression equations, based on the dental measurements of 200 males and 200 females, were developed for predicting the sum of the mesio-distal widths of unerrupted canine and premolar segments for both maxillary and mandibular dental arches during the mixed dentition period for the population of study sample. The following are the equations in this study for prediction:

The equation is Y = a+b.(x)

For LCPM width

1. Y= 17.204+0.174.(x) - Males
2. Y= 13.431+0.330.(x) - Females

For UCPM width

1. Y=16.904+0.209.(x)—Males
2. Y=15.627+0.263.(x)--Females

Tables 4 & Table 5: Graphically when comparing Moyer's tables and the new probability tables at the 50% probability level for males (Fig 1 & Fig. 2) in the maxilla and mandible, the slopes from the lines connecting the predicted data are crossing over. As the slopes of the two sets of predicted data differ, the lines tend to cross each other. This implies that if the sum of the lower incisors is less than 23.5mm, the predicted size for canines and premolars is

Table 6: Summation of M-D widths of mandibular incisors and maxillary and mandibular canine premolar segments from various studies

Study	Sex	Sample(n)	Arch	Mean(mm)	SD(mm)
Jaroontham and Godfrey (Thai)[26]	M	215	LI	23.89	1.37
			UCPM	23.31	1.03
			LCPM	23.16	1.04
	F	215	LI	23.23	1.26
			UCPM	21.77	1.02
			LCPM	22.64	1.00
Schirmer and Wiltshire (South African)[18]	M	50	LI	23.92	1.90
			UCPM	23.45	1.37
			LCPM	23.22	1.11
	F	50	LI	23.66	1.59
			UCPM	22.20	1.24
			LCPM	22.28	1.28
Frankel and Benz (Black American)[15]	M	39	LI	23.06	1.59
			UCPM	22.57	1.45
			LCPM	22.53	1.30
	F	41	LI	22.94	1.28
			UCPM	21.58	0.94
			LCPM	21.78	0.83
Yuen et al (Hong Kong Chinese)[2]	M	51	LI	23.15	1.25
			UCPM	22.30	0.39
			LCPM	23.37	1.10
	F	46	LI	23.28	1.22
			UCPM	21.58	1.16
			LCPM	22.67	1.09
Present Study (Bangalore)	M	200	LI	23.87	2.15
			UCPM	21.89	0.89
			LCPM	21.36	0.63
	F	200	LI	23.51	1.43
			UCPM	21.82	0.90
			LCPM	21.18	0.95

smaller for Bangalore subjects as predicted by Moyer's tables. The tooth sizes for males fall in a high range. The male subject's canines and premolars are approximately 1mm larger per quadrant than predicted by the Moyer's probability tables. Graphically when comparing Moyer's tables and the new probability tables at the 50% probability level for females (Fig 3, and 4) in the maxilla and mandible, the sizes of canines and premolars of the Bangalore subjects are larger than those predicted by the Moyers tables. The difference is approximately 1mm per quadrant.

DISCUSSION

This study was done to assess the reliability of the Moyer's prediction chart as well as to generate a prediction table suitable for the local ethnic Kannada speaking population. In order to ensure the reliability of the data a sufficiently large sample size was taken (n=400), between the age

Table 7: Regression parameters from various investigations

Study	Sex	Arch(y)	r	Constant a	Constant b	SEE(mm)	R^2
Jaroontham and Godfrey (Thai)[26]	M	Mandible	0.58	11.92	0.43	0.85	0.34
		Maxilla	0.54	13.36	0.41	0.88	0.29
	F	Mandible	0.65	9.49	0.53	0.78	0.42
		Maxilla	0.62	11.16	0.49	0.78	0.39
	M+F	Mandible	0.64	10.30	0.50	0.82	0.41
		Maxilla	0.60	11.87	0.47	0.84	0.36
Furguson et al (Negro)[16]	M+F	Maxilla	0.62	11.93	0.44		0.38
		Mandible	0.70	9.93	0.52		0.49
	M	Maxilla	0.72	9.15	0.58	0.92	0.51
		Mandible	0.79	5.97	0.72	0.91	0.62
Frankel and Benz (Black Americans)[15]	F	Maxilla	0.61	12.83	0.39	0.67	0.37
		Mandible	0.70	10.34	0.49	0.70	0.43
	M+F	Maxilla	0.65	10.18	0.52	0.87	0.42
		Mandible	0.70	8.30	0.64	0.94	0.49
Yuen et al (Hong Kong Chinese)[2]	M	Maxilla	0.79	7.97	0.66	0.68	0.62
		Mandible	0.77	8.82	0.58	0.61	0.60
	F	Maxilla	0.65	8.30	0.61	0.81	0.42
		Mandible	0.69	6.66	0.64	0.82	0.47
Al Khadra (Saudi Arab)[27]	M+F	Maxilla	0.65	7.20	0.63		0.42
		Mandible		8.60	0.55		0.49
Present study (Bangalore)	M	Mandible	0.59	17.20	0.17	0.51	0.35
		Maxilla	0.50	16.90	0.20	0.77	0.25
	F	Mandible	0.49	13.43	0.33	0.82	0.24
		Maxilla	0.41	15.62	0.26	0.82	0.17

13 to 16 yrs is representative of the local ethnic population. This was a longitudinal study that assessed the tooth size correlation between lower incisors and the posterior segments. Definite racial and ethnic differences in tooth size have been emphasized in several studies.[21] The prediction tables formulated at the University of Michigan, which are based on data derived from population of Northern European descent, is neither accurate nor applicable when applied to a population of different ethnic origin. Multiple regression analyses have indicated that the sum of

the mesiodistal width of the four mandibular permanent incisors is the best predictors for unerrupted canines and premolars.[22] Fortunately, these are the teeth that are among the first to erupt during the early mixed dentition. It is the ease of Moyer tables that makes them clinically attractive the mesiodistal width of the four mandibular permanent incisors is the best predictors for unerrupted canines and premolars.[22] Fortunately, these are the teeth that are among the first to erupt during the early mixed dentition. It is the ease of Moyer tables that makes them clinically attractive and popular and an effective method to predict the mesio-distal dimensions of unerrupted maxillary and mandibular canines and premolars.

The predicted sum of the mesio-distal widths of unerrupted canines and premolars can be read at the probability level of the practitioner choice. The 75% percentile level is recommended by Moyer's and generally used. This means that in 75% of cases, the unerrupted canines and premolars will be at the predicted value or less.[23] The correlation between the mesio-distal width of erupted mandibular incisors and mesio-distal width of erupted canines and premolars showed a fair correlation. Realizing the importance of diagnosing the arch size to tooth size discrepancy at an early stage, many investigators have formulated criteria for predicting the size of unerrupted permanent teeth. Moyers, Ballard and Wylie and Nance used the mesio-distal width of erupted permanent mandibular incisors for the prediction of the mesiodistal width of unerrupted canines and premolars. Moyers prediction tables were mainly formulated for the American Whites and he chose the 75% level of probability since it was the most practical from the clinician stand point. Moyers sample has not been characterized in the literature. While applying Moyers prediction tables to a section of the south Indian population, Rani and Goel,[24] found it to be more applicable at the 35% level instead of 75% as observed by Moyers for his sample. Aggrawal and Chopra,[25] formulated their own prediction tables and graphs for a section of the North Indian population which can be used to determine the combined mesio-distal width of canine and premolar against the total width of erupted mandibular incisors. The present study showed that 50% probability is more applicable for boys and 75% for girls. Since the literature is lacking in the formulation of such prediction tables for its own population, keeping in view the racial, geographic and other differences from those of the Americans, the present study attempted to formulate a prediction table for the children of Bangalore. In this study, separate tables were formulated for males and females separately. The mesio-distal crown dimensions of the teeth for men and women from various studies in both arches are presented in Table 6. The combined mesio-distal crown diameters of the canine and premolar segments and the mandibular incisors seemed relatively smaller than those of black South Africans, whose teeth are the largest of all groups, but comparable to those African Americans, Thai,[26] and Hong Kong Chinese groups. Definite racial and ethnic differences in tooth size have been emphasized in several studies. Descriptive statistics also showed that the mesio-distal diameters of the mandibular incisors and the maxillary and mandibular canine and premolar segments were greater in men than in women ($P<0.05$). Significant sexual dimorphism has also been noted in other studies.[26] **Table 6:** Shows r values for the buccal segments of each arch, constants 'a' and 'b', the SEE, and the r2 of the maxillary and the mandibular regression equations from different investigations. The correlation coefficients for the Bangalore subjects between the buccal segments of each arch and the mandibular incisors were found to be smaller than for Hong Kong Chinese and the Thai population.

Relative comparison of regression parameters from different studies showed the regression parameter 'a' is comparatively greater than other studies. This study showed greatest (17.20) and the least (13.43) constant 'a' values in the mandible in females. The r2 values are the indicators of predictive accuracy of the regression equations. This study showed lesser r2 values for both the arches than Thai population and Hong Kong Chinese. The SEE indicate the error in use of prediction equations. In this study the SEE ranged from (0.51 to 0.82) comparatively lower than the findings of other investigations. **Table 7**: Predicted values from the new proposed probability tables for Bangalore subjects indicate that the mesio-distal tooth sizes of canines and premolars are larger than those of incisors are similar. These findings value were supported by Mertz *et al*.[28] It is recommended that the

proposed new probability tables be considered for Bangalore subjects because the Moyers prediction tables may adversely effect the space assessment in the population. Permanent teeth may be either inappropriately retained or extracted on the basis of such an inaccurate tooth width prediction. Assistance in the development of a wound diagnosis remains the cornerstone of successful treatment. This study showed that Moyers prediction tables under predicted the sizes of canines and premolars in females, and in the mandible if the sum of the mandibular incisors is less than 23.5mm, the Moyers tables under predicted the size of canines and premolars in males. The prediction tables formulated based on data from Bangalore population, should be accurate when applied to local children, despite the ethnic diversity of Bangalore. The prediction table is convenient to use and does not require memorizing the equations. Further investigation has to be done to evaluate the accuracy of the proposed prediction tables in local population and its application to other ethnic groups in Bangalore.

CONCLUSION

The mean value of lower incisor for female sample was 23.51±1.43, for UCPM was 21.82±0.90, and for LCPM was 21.18± 0.95. The mean value of lower incisor for male sample was 23.87± 2.15, for UCPM was 21.89±0.89 and for LCPM was 21.36±0.63. Significant sexual dimorphism in tooth sizes exists in study sample. 33 discrepancy observed could be the result of racial diversity in study sample. In this study it was found that 50% probability level is more applicable to boys and 75% probability level to girls than the Moyer's probability table. Odontometric data was developed for the local study sample, the prediction table separate for boys and girls were developed. The specific probability tables proposed here for Bangalore children should be accurate when applied to local children, despite the ethnic diversity of Bangalore. The accuracy of the proposed prediction tables should be tested in a large sample of the local population and various other ethnic groups in Bangalore.

CONFLICT OF INTEREST & SOURCE OF FUNDING

The author declares that there is no source of funding and there is no conflict of interest among all authors.

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