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Novel Prediction Equations for Estimating Widths of Mandibular and Maxillary Canine and Premolar from Maxillary First Permanent Molar and Mandibular Incisor Widths: Digital Model Study

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Abstract

Objectives: The prime goal of our study was constructingnovel prediction equation for the estimation widths of maxillary and mandibular canine and premolar from maxillary first permanent molar and mandibular incisor widths.

Methods: The selected sample consisted of 128 subjects with the age ranging from 18-24 years. Total variables measured were 2,304. Individual subjects dental models for maxillary as well mandibular arch were scanned by Hirox digital stereomicroscope (HIROX KH7700 Japan) for production of the digital models. Maxillary, mandibular canine and premolars width mesiodistally were carried out by digital models.

Results: There was high positive correlation found for estimating the width of mandibular and maxillary canine and premolar from the sum of first permanent maxillary molar and width of mandibular incisor (MandI+Max66). The linear regression analysis was used for the creation of prediction equations. The novel prediction equation were developed aimed at estimating maxillary arch as Y= 14.531+0.661 × (MandI+Max66), Y= 14.878+0.645 × (MandI+Max66) and Y= 17.173+0.608 × (MandI+Max66). The novel prediction equation developed estimated the mandibular arch as Y= 13.939+0.649 × (MandI+Max66), Y= 15.061+0.628 × (MandI+Max66) and Y= 14.576+0.630 × (MandI+Max66).

Conclusions: The investigated prediction equations will be useful in planning the clinical treatment in orthodontics during mixed dentition analysis.

Keywords

Mesio-distal tooth size; Mixed dentition analysis; Prediction equations; Digital dental model

Introduction

To achieve decent occlusion with accurate inter-digitation, vertical plus horizontal relation, the requirement is an ideal mesiodistal dimension of teeth to seat in good occlusion [1]. Dental malocclusion is an exceptionally normal issue in the global populations. In spite of the fact that manner of malocclusion fluctuates in distinctive populace, one of the vital etiological factor considered is the tooth size arch length discrepancy. If the dimension of the arch and size of tooth is anticipated precisely before occurrence of malocclusion the estimation then can be used to decrease or forestall the malocclusion seriousness. It can be done by one of the following ways like guiding the eruption, doing serial extraction, space maintenance, gaining of the space or observing patient periodically for orthodontic treatment [2]. A number of methods has been in use for predicting mesiodistal width of unerupted tooth in orthodontic treatment planning, like radiographic method [3,4], dental models method [5-8], and dental models, radiographic methods together [9,10]. The objective of this study wasproducing novel prediction equation for width estimation of maxillary, mandibular canine and premolar from maxillary first permanent molar and mandibular incisor widths, correspondingly to observe the accompanying objectives for the first time in Pakistani population.

a) To assess the extent of sexual dimorphism for width of crown mesiodistally (MD) of mandibular and maxillary canines and premolars.

b) To assess the extent for side disparities for width of crown mesiodistally (MD) for maxillary, mandibular canines and premolars.

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c) To conclude novel prediction equations for estimating width of crown mesiodistally (MD) for maxillary canines and premolars in females, males and in combination.

d) To conclude novel prediction equations for estimation of width of crown mesiodistally (MD) for mandibular canines and premolars in females, males and in combination.

Materials and Methods

Ethical approval was approved by Universiti Sains Malaysia Ethics Committee (USM / JEPeM / 140376) with strictly following all ethical protocols. Before commencing the study, informed consent was also obtained from study subjects. Our exploration study was composed and directed by rules of STROBE (Strengthening the Reporting of Observational studies in Epidemiology)andwe applied STROBE specifications in our study [11].

Sample size calculation

Sample size was calculated at power of 80%, by applying estimated standard deviations of 0.60mm [12], biologically meaningful mean difference of 0.3mm, and identical sample sizes [13]. Calculated sample size were of 128 subjects (64 females and 64 males with mean age 19.4 ± 1.9 SD). The inclusion plusthe exclusion criteria being used is as follows.

Inclusion criteria

i. All patients' origin was Pakistan determined by interviews, common paternities and ancestors were without any multi-ethnic marriages.

ii. Subjects were aged from 18 - 24 years.

iii. Well aligned maxillary, mandibular arches, showing normal growth pattern and development.

iv. None of the participants had undertaken orthodontic treatment, with all permanent teeth being sound and erupted (except third molars).

v. Ideal occlusion along with Class I molar plus canine relationship with incisors in accordance with British Standards Institute [14].

vi. No spacing, cross bite and crowding.

vii. Straight profile (identify by examination of the profile view).

viii. Not any craniofacial abnormalities.

Exclusion criteria

a. Interproximal restorations or caries.

b. Any missing or supernumerary teeth.

c. Abnormal morphology or size of teeth.

d. Tooth wear which affected the measurements of the tooth size.

e. Any destruction to the casts.

Dental as well as oral investigations were carried out by carefully selecting the participants. Cross-examination of the participants were done for diminishing bias and error in sample; with the help of a skillful dentist, orthodontist who contributed during the course ofsittings of the screening. Upper and lower arches dental impressions of each participant was attained with the help of alginate impression material (ZhermackOrthoprint alginate ISO 1563 –ADA 18 Italy) and poured with Type III hard plaster quick stone China (Dental Stone) according to the manufacturer's guidelines. Total variables measured were 2,304.

Tooth Size Measurement

The dental models of mandibular and maxillary arches of each subject were scanned by Hirox digital stereomicroscope (SM) (HIROX KH7700 Japan) to fabricate digital models (Figure 1a). SM digital models were used for tooth size of both maxillary as well mandibular teeth. SM is a very reliable, valid and well reputed tool for these kind of measurements having accuracy 0.1×10-6 mm [15]. Teeth size measurement acquisition was as following:

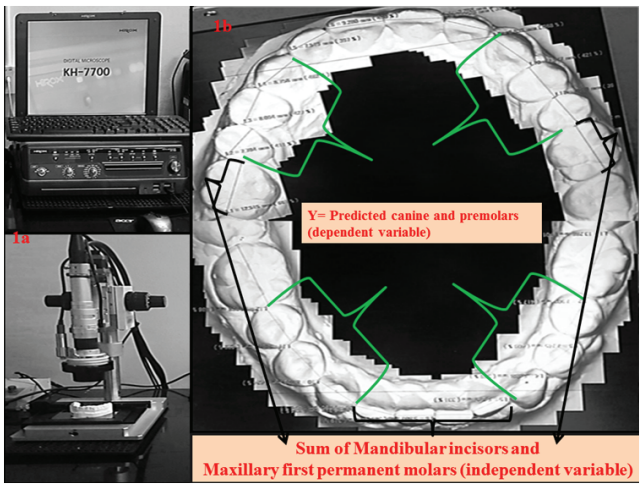

Figure1: Fabrication of digital models (1a) stereomicroscope (1b) Sum of mesiodistal crown diameter for dependent and independent variables

Crown diameters MD(Figure 1b)

The diameter of tooth crown measured mesiodistally was from anatomical contact of one tooth to another on occlusal side which is perpendicular to the long axis of the teeth [16,17]. The dependent variables of the study were sum of the diameters of maxillary canine and premolars crown mesiodistally (SMaxCPM), sum of the diameters of mandibular canine and premolars crown mesiodistally (SMandCPM). The variable being independent was, sum of width of mandibular incisors and first permanent molars (MandI+Max66) (Figure 1b).

Study Error

Digital dental casts indiscriminately selected for intra-observer errors were 20%. The time interval was approximately two weeks between the first and second readings. Dalhberg's formula was used for analyzing the method error (ME) which is as follows: ME = (Σ (x1-x2)2/ 2(28))1/2. Where first measurement is x1 and x2 being second measurement [18].

Statistical analyses

Data was analyzed and confirmed statistically by IBM SPSS Statistics Version 22.0 (Armonk, NY: IBM Corp.) with confidence level being set at 5% ($P < 0.05$) for testing the significance. An independent t-test was used for determining any gender difference for the MD crown dimensions. There was use of paired t-test for comparing the side disparities. Linear regression equations wasalso used for generating prediction equation.

Results

Error of the measurements method

The Dalhberg's formula was used for analyzing the method error which showed the values of 0.006 mm for a mesiodistal width measurement is within acceptable range.

Canines and premolars sexual disparities

Table 1 shows significant sexual disparities for maxillary, mandibular canines and premolars. The canines and premolars,

Variables	Sex	N	Mean	SD	95% CI		P
					Lower	Upper	
MD 13	M	64	8.00	0.46	0.13	0.46	0.00
	F	64	7.71	0.48			
MD 14	M	64	7.06	0.46	0.05	0.35	0.01
	F	64	6.86	0.41			
MD 15	M	64	6.73	0.46	-0.08	0.25	0.33
	F	64	6.65	0.49			
MD 23	M	64	7.97	0.44	0.15	0.47	0.00
	F	64	7.66	0.49			
MD 24	M	64	7.12	0.47	0.05	0.35	0.01
	F	64	6.92	0.41			
MD 25	M	64	6.73	0.47	-0.02	0.31	0.09
	F	64	6.59	0.48			
MD 33	M	64	7.10	0.40	0.13	0.43	0.00
	F	64	6.82	0.48			
MD 34	M	64	7.07	0.45	-0.08	0.22	0.36
	F	64	7.00	0.40			
MD 35	M	64	7.07	0.45	-0.04	0.27	0.15
	F	64	6.95	0.46			
MD 43	M	64	7.03	0.43	0.11	0.41	0.00
	F	64	6.77	0.43			
MD 44	M	64	7.07	0.45	-0.07	0.22	0.31
	F	64	7.00	0.39			
MD 45	M	64	7.03	0.46	-0.02	0.29	0.09
	F	64	6.90	0.44			

FDI notation;** MD, mesiodistal crown diameters; M, male; F, female; N, numbers of sample CI, confidence interval; SD, standard deviation; SE, standard error.(p≤ 0.001), (**p≤ 0.01) and (*p≤ 0.05).

Table 1: Sexual dimorphism in maxillary and mandibular canine and premolars

displayed meaningfully bigger values for males in relation to females (*p≤ 0.05 to ***p≤ 0.001).

Canines and premolars side's disparities

Table 2 & 3 show no side disparities for MD width of maxillary, mandibular canines and premolars for females and males respectively, with the exception of female maxillary canine (*p=.043).

Prediction equation for mandibular and maxillary arches

Table 4 & 5 shows novel prediction equation for estimating width of maxillary, mandibular canine and premolar from maxillary first permanent molar and mandibular incisor widths for males, females and in combination respectively.

Accuracy of Linear regression formula

Figure 2 & 3 shows the proposed formula accuracy for estimating widths of maxillary and mandibular canine and premolar from maxillary first permanent molar and mandibular incisor widths for males, females then in combination respectively.

Discussion

During period of mixed dentition, predicting value of mesiodistal dimensions (MD) of the unerupted permanent teeth remains of great significance in diagnosing plus treatment planning. For dealing and treating tooth size/arch length discrepancies accurate assessment of size of the un-erupted tooth allows better treatment planning [19]. Arch dimension analysis and tooth size direct measurement analysis for mixed dentition include graphs, scales and hand held calipers for recording dimensions and size of the tooth on dental casts has been in use[20]. It is now possible that dental casts can be replicated in form of digital dental models because of the advancements in technology [20,21]. We can now have more reliable and accurate tools in attaining measurements in addition to dental analysis by using these digital model studies [15,22]. Furthermore, digital model studies have additional benefits, like reduction in storage costs, accessibility of the images produced, and sophisticated software's to analyze images [22,23]. Literature shows us reports of many methods aimed at predicting MD width of unerupted canine plus premolars, regression equations which is based on erupted permanent teeth

Variables	Mean	N	SD	SE	95%CI		P
					Lower	Upper	
MD 13	8	64	0.46	0.06	-0.02	0.09	0.25
MD 23	7.97	64	0.44	0.06			
MD 14	7.06	64	0.46	0.06	-0.11	0	0.064
MD 24	7.12	64	0.47	0.06			
MD 15	6.73	64	0.46	0.06	-0.06	0.06	0.984
MD 25	6.73	64	0.47	0.06			
MD33	7.1	64	0.4	0.05	0	0.15	0.064
MD 43	7.03	64	0.43	0.05			
MD 34	7.07	64	0.45	0.06	-0.06	0.05	0.792
MD 44	7.07	64	0.45	0.06			
MD 35	7.07	64	0.45	0.06	-0.04	0.11	0.333
MD 45	7.03	64	0.46	0.06			

***FDI notation;** MD, mesiodistal crown diameters; N, numbers of sample CI, confidence interval; SD, standard deviation; SE, standard error.

Table 2: Malesside disparities

Variables	Mean	N	SD	SE	95%CI		P
					Lower	Upper	
MD 13	7.71	64	0.48	0.06	0.002	0.104	0.043
MD 23	7.66	64	0.49	0.06			
MD 14	6.86	64	0.41	0.05	-0.117	0.005	0.07
MD 24	6.92	64	0.41	0.05			
MD 15	6.65	64	0.49	0.06	-0.013	0.133	0.105
MD 25	6.59	64	0.48	0.06			
MD33	6.82	64	0.48	0.06	-0.029	0.13	0.207
MD 43	6.77	64	0.43	0.05			
MD 34	7	64	0.4	0.05	-0.062	0.062	0.995
MD 44	7	64	0.39	0.05			
MD 35	6.95	64	0.46	0.06	-0.032	0.143	0.208
MD 45	6.9	64	0.44	0.05			

*FDI notation; MD, mesiodistal crown diameters; N, numbers of sample CI, confidence interval; SD, standard deviation; SE, standard error.

Table 3: Female Sides disparities

Gender	Prediction equations
Combined male and female	Y= 14.531+0.661 × (MandI+Max66)
Male	Y= 14.878+0.645 × (MandI+Max66)
Female	Y= 17.173+0.608 × (MandI+Max66)

Y, dependent variable for canines and premolars; MandI+Max66, sum of maxillary first permanent molar and mandibular incisor widths (independent variable)

Table 4: Prediction equation for maxillary arch

Gender	Prediction equations
Combined male and female	Y= 13.939+0.649 × (MandI+Max66)
Male	Y= 15.061+0.628 × (MandI+Max66)
Female	Y= 14.576+0.630 × (MandI+Max66)

Y, dependent variable for canines and premolars; MandI+Max66, sum of maxillary first permanent molar and mandibular incisor widths (independent variable)

Table 5: Prediction equation for mandibular arch

in period of early mixed dentition were broadly used for predicting widths of unerupted canine as well as premolars [7,19,24]. Therefore, current study investigates novel prediction equation for estimating widths of maxillary and mandibular canine, premolar from maxillary first permanent molar and mandibular incisor widths for the very first time through digital dental models (Table4 and 5). Current investigation and measurements were carried out through the SM digital dental models acquisitions being valid as well a reliable tool for such type of measurements [15].

Current study observed sexual dimorphism for canine and premolar of both arches. However, no side differences were found between them (with exception of maxillary canine in females). Reviewing the orthodontic literature it was discovered that sexual disparities in size of teeth of various populations along with genders. It was discovered that male teeth were larger than females [17]. Though numerous researchers did not witnessed any sexual disparities [9,25]. On the other hand, other investigators found substantial sexual disparities for the mesiodistal tooth dimension with males have larger teeth [6,8,24,26]. This demands gender distribution of subjects when acting out this kind of predictions in orthodontics mixed dentition analysis. This study revealed gender dimorphism in tooth widths, thus data was analyzed individually for males and then females.Various researchers reported side differences for teeth size of mandibular and maxillary arches (27-29). Though few others found no noteworthy side differences in comparison of tooth size (19,30). For the comparison of the right and then left side mandibular and maxillary teeth size, it was detected and found asymmetries for female maxillary canine only. Therefore, all the prediction equations were scrutinized for predicting canine and premolar of both (left, right) sides in maxilla and mandible.

Current research investigated the new formula through digital dental models.Linear regression formula accuracy, estimation widths of maxillary, mandibular canine and premolar from maxillary first permanent molar and mandibular incisor widths were within highly acceptable limit (Figure 2 &3). The novel prediction equation were established for estimating maxillary arch as Y= 14.531+0.661 × (MandI+Max66), Y= 14.878+0.645 × (MandI+Max66) and Y= 17.173+0.608 × (MandI+Max66) the average error of prediction were -0.125, -0.678 and -0.532mm respectively. The novel prediction equation were established for the estimating mandibular arch as Y= 13.939+0.649 × (MandI+Max66), Y= 15.061+0.628 × (MandI+Max66) and Y= 14.576+0.630 × (MandI+Max66) the average error of prediction were -0.012, 0.029 and -0.755 mm respectively. This investigation may be of great value and assist in diagnosing and treatment planning for the Pakistani orthodontist to treat the patients at mixed dentition stage in this digital era. The provided prediction equation will show its usefulness in clinical treatment planning of orthodontic. Though accuracy of the investigated equation through digital dental models need to be tested in larger sample size from different ethnic groups of Pakistan for generalizing its relevancy further. As the mesiodistal diameters of crown showed sexual disparities, showing consistency with published studies for different ethnic groups (17, 31-35). Fact that there is variation in size of tooth and advancement in digital dental models, there is need of carrying out likewise research on other populations to help as an aide for the diagnosis and treatment planning in orthodontics for analysis of mixed dentition.

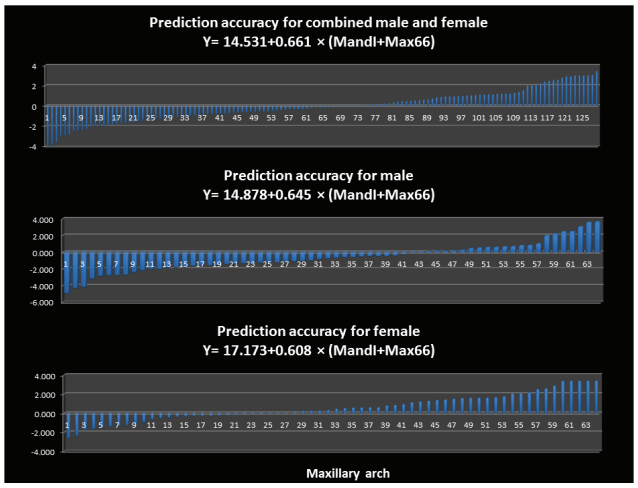

Figure 2: Accuracy of suggested prediction equation (Maxillary Arch)

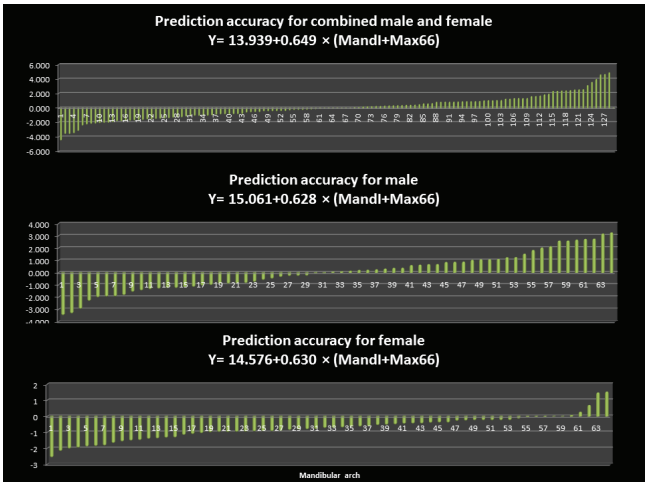

Figure 3: Accuracy of suggested prediction equation(Mandibular Arch)

Conclusion

a. Sexual dimorphism was reveled for width of mesiodistal (MD) crown of maxillary, mandibular canines and premolars.

b. No side disparities found for width ofmesiodistal (MD) crown of maxillary, mandibular canines and premolars, with exception of female maxillary canine (*p=.043).

c. New prediction equation was determined to estimate width of mesiodistal (MD) crown of maxillary canines plus premolars in females, males then in combination.

d. New prediction equation was determined to estimate width of mesiodistal (MD) crown of mandibular canines plus premolars in females, males then in combination.

e. The novel prediction equation were developed for predicting MD of maxillary canine, premolarfrom mesiodistal width of mandibular incisors asY= 14.531+0.661 × (MandI+Max66), Y= 14.878+0.645 × (MandI+Max66) and Y= 17.173+0.608 × (MandI+Max66).

f. The novel prediction equation were developed for predicting MD of mandibular canine plus premolar from mesiodistal width of mandibular incisors asY= 13.939+0.649 × (MandI+Max66), Y= 15.061+0.628 × (MandI+Max66) and Y= 14.576+0.630 × (MandI+Max66).

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