Original

A New Method to Measure and Assess Tooth Size and Tooth Size Discrepancy Via Circumferential Measurements using Stereomicroscope

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Abstract: An accurate evaluation of tooth size and tooth size discrepancy is critically important in orthodontic diagnosis and treatment planning. The purpose of this study was to establish a new method to measure and assess tooth size and tooth size discrepancy with accuracy and reproducibility, named as circumferential tooth size (CFT), circumferential anterior tooth size ratio (CAR), circumferential overall tooth size ratio (COR) respectively. Total 128 dental models were scanned via Hirox digital stereomicroscope for the fabrication of the digital models. Dental models were selected on the basis of inclusion criteria. All the measurements were obtained with the accuracy of 0.1×10^{-6} mm; the mean and the SD for the CFT, CAR and COR were calculated. The developed norms for the CFT, demonstrated significantly greater values for males in relation to females. More precisely, there were statistically significant differences observed in different variables ($*p \leq 0.05$ to $***p \leq 0.001$). CAR and COR ratio show slight greater value for males without any statistically significant differences. The findings provide valuable information that CFT cover the tooth size in all dimensional aspects. For the prediction of ideal occlusion to be achieved at the finishing stage, orthodontist needs to evaluate CAR and COR ratios via proposed method.

Key words: Circumferential tooth size, Tooth size discrepancy, Digital dental models.

Introduction

In orthodontic diagnosis and treatment planning, great importance has been attached to evaluating the tooth size and tooth size discrepancy. Linear measurements have been incorporated into various dental model analyses to help the clinician to measure the tooth size and tooth size discrepancies to establish the most appropriate treatment plan¹⁻³⁾.

Variations in tooth size and tooth size ratio have been connected with diverse ethnic foundations and occlusion status⁴⁻⁹⁾. Inter maxillary tooth size discrepancy is not infrequent in many populations^{1,10,11)}. From a clinical point of view, ideal balance ought to exist between the mesiodistal tooth sizes of the maxillary and mandibular arches to assure correct interdigitation, overbite and overjet at the consummation of orthodontic treatment¹²⁻¹⁴⁾.

The time in which the orthodontic practice is currently being known as “digital era” the computerized advances are no doubt used to resolve the past confinement of the patient record keeping

and management¹⁵⁾. Digital models have facilitated the automated calculation of tooth size ratios once the mesial and distal points of each tooth have been identified¹⁶⁻²¹⁾. Digital models have advantages of being faster and providing easier storage of data^{14, 22)}. Digital study models have been found to be an appropriate alternative to those derived using plaster models and digital calipers^{14,16-18,23)}.

Analysis of tooth size discrepancy^{24,25)} is of extraordinary importance for orthodontic diagnosis and treatment planning and considered as a seventh “key” to occlusion²⁶⁾. Some studies investigated race and sex differences^{1,5)}. Other authors have suggested no significant differences in the tooth size ratio with different malocclusion^{10,27,28)}.

A specific measurement should assess the tooth size and tooth size discrepancy, independent of mesiodistal, buccolingual and diagonal linear measurements. Our study investigated a new method to measure the tooth size and tooth size discrepancy and named as circumferential tooth size (CFT), circumferential anterior tooth size ratio (CAR), circumferential overall tooth size ratio (COR) respectively. CFT, CAR and COR do not depend on any

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Figure 1. Circumferential tooth size measurement

Figure 2. Hirox digital stereomicroscope

Figure 3. Fabrication of the digital models via hirox digital stereomicroscope and circumferential tooth size measurements

linear measurement, CFT would be especially valuable whenever previously established tooth size measurements, such as the mesiodistal, buccolingual and diagonal cannot be used accurately because of their dependence on varying factors like caries and tooth wear.

The CFT, CAR and COR

The CFT, CAR and COR are the new measurements for assessing the tooth size and tooth size discrepancy of the maxilla and the mandible via digital dental models.

CFT

The CFT can be found by locating the maximum perimeter of the tooth (Fig. 1).

CAR and COR

The CAR and COR can be used to identify the tooth size discrepancy. For CFT in orthodontics CAR and COR can be obtained by the following formula

$$CAR = \frac{\text{sum of CFT mandibular 3 to 3}}{\text{sum of CFT maxillary 3 to 3}} \times 100$$

$$COR = \frac{\text{sum of CFT mandibular 6 to 6}}{\text{sum of CFT maxillary 6 to 6}} \times 100$$

The purposes of this study were to establish the norms for Pakistani population with regard to CFT, CAR and COR using stereomicroscopic digital dental models. In addition to the norms of circumferential dimensions and ratios, the sex and side differences were also investigated.

Materials and Methods

Dental impression and personal information were collected only after informed consent has been obtained from the subjects. This study was approved by the Human Ethics Committee of the Universiti Sains Malaysia (USM). Current research was outlined and directed as indicated by the rules of strengthening the Reporting of Observational studies in Epidemiology (STROBE), and we used the STROBE guidelines in this manuscript²⁹.

Sample size calculation

Sample size were calculated based on our pilot study by using PS software³⁰. The parameters were as follow: power 0.8, significant level 0.05, standard deviation (from the pilot study) 1.8mm, mean difference 0.9mm and equal ratio between groups. The estimated sample size was 64 females and 64 males. Three thousand five hundred eighty-four variables were measured with the following inclusion and exclusion criteria.

Inclusion criteria

The inclusion criteria include healthy subjects with age between 18 – 24 years, having full dentition in both arches excluding the third molars, no history of orthodontic treatment, ideal occlusions with class I incisor relationship according to British standards institute, class I molar and canine relationship, no crowding, no spacing, no rotations along with good quality study models for digital scanning and acquisitions were selected.

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Table 1. Norms based Circumferential Tooth Size Measurements

Variables*	Male		Female		Mean diff.	95% CI		P	
	Mean	SD	Mean	SD		Lower	Upper		
11	27.24	1.82	25.75	1.73	1.49	0.89	2.09	.001	***
12	22.47	1.78	21.52	1.84	0.95	0.35	1.56	.002	**
13	25.60	1.75	24.41	1.79	1.20	0.60	1.79	.001	***
14	27.35	2.02	26.24	1.94	1.10	0.44	1.77	.001	***
15	26.76	1.84	25.50	2.10	1.26	0.60	1.92	.001	***
16	37.32	2.31	35.88	1.73	1.43	0.74	2.12	.001	***
17	31.98	2.91	29.92	3.02	2.06	1.06	3.06	.001	***
21	27.24	1.82	25.75	1.73	1.49	0.89	2.09	.001	***
22	22.47	1.78	21.52	1.84	0.95	0.35	1.56	.002	**
23	25.60	1.75	24.41	1.79	1.20	0.60	1.79	.001	***
24	27.34	2.02	26.24	1.94	1.10	0.43	1.77	.001	***
25	26.76	1.83	25.50	2.10	1.26	0.60	1.92	.001	***
26	37.32	2.31	35.88	1.73	1.43	0.74	2.12	.001	***
27	31.98	2.91	29.92	3.02	2.06	1.06	3.06	.001	***
31	19.32	1.54	18.34	1.64	0.99	0.45	1.52	.001	***
32	20.12	1.36	18.97	1.49	1.15	0.67	1.63	.001	***
33	23.08	1.44	21.48	1.84	1.60	1.05	2.15	.001	***
34	23.90	1.68	23.02	1.81	0.89	0.30	1.47	.003	**
35	25.34	1.55	24.43	2.11	0.91	0.29	1.53	.004	**
36	36.18	2.30	34.18	4.08	2.00	0.91	3.09	.001	***
37	33.57	2.64	32.38	2.26	1.19	0.36	2.02	.005	**
41	19.32	1.54	18.34	1.64	0.99	0.45	1.52	.001	***
42	20.12	1.36	18.97	1.49	1.15	0.67	1.63	.001	***
43	23.08	1.44	21.48	1.84	1.60	1.05	2.15	.001	***
44	23.90	1.68	23.02	1.81	0.89	0.30	1.47	.003	**
45	25.34	1.55	24.43	2.11	0.91	0.29	1.52	.004	**
46	36.18	2.30	34.18	4.08	2.00	0.91	3.09	.001	***
47	33.57	2.64	32.38	2.26	1.19	0.36	2.02	.005	**

*FDI notation; CI: confidence interval; SD: standard deviation; Mean diff.: mean differences (**p ≤ 0.001), (*p ≤ 0.01) and (*p ≤ 0.05).

Table 2. Right and Left Comparison for Circumferential Measurements

variables	Mean diff.	SD	Maxilla			P	Mean diff.	SD	Mandible		P
			95% CI		95% CI						
			Lower	Upper	Lower				Upper		
CI	0.01	.004	-.001	.001	.946	0.01	.002	-.001	.000	.224	
LI	0.01	.005	.000	.001	.303	0.01	.002	.000	.001	.258	
CI	0.01	.004	-.001	.001	.963	0.01	.004	.000	.001	.221	
IPM	0.01	.007	-.001	.002	.584	0.01	.003	-.001	.000	.328	
2PM	0.01	.002	-.001	.000	.504	0.01	.003	-.001	.000	.151	
IM	0.01	.002	-.001	.000	.028	0.01	.003	.000	.001	.741	
2M	0.01	.003	-.001	.000	.392	0.01	.003	-.001	.000	.106	

CI: central incisor; LI: lateral incisor; C: canine; IPM: 1st premolar; 2PM: 2nd premolar; IM: 1st molar; 2M: 2nd molar;

CI: confidence interval; Mean diff.: mean differences; SD: standard deviation.

Table 3. CAR and COR Ratios with Sexual Dimorphism.

	Sex	Mean	SD	SE	95%CI		p
					Lower	Upper	
CAR	M	83.09	3.52	0.41			
	F	82.05	4.01	0.50	-0.23	2.30	0.107
COR	M	88.79	3.13	0.36			
	F	88.16	5.27	0.66	-0.80	2.06	0.385

CAR: circumferential anterior ratio; COR: circumferential overall ration; CI: confidence interval; SD: standard deviation; SE: standard error mean.

Exclusion criteria

Subject who have inter proximal caries or restoration, missing or supernumerary teeth, teeth wear that affect the tooth size measurement and damage casts were excluded. Dental impressions of the upper and lower arches of the each subject were taken with alginate impression material (Zhermack Orthoprint alginate ISO 1563 –ADA 18 made in Italy) and poured with dental stone (Type III hard plaster quick stone made in China) in accordance with the manufacturer's instructions and labeled accordingly.

Error study

20 % of dental cast were randomly selected for intra observer errors. The time interval between the first and second reading were approximately 2 weeks. The method error was analyzed by the Dahlberg's double determination formula³¹⁾. $ME = \frac{\sum (x_1 - x_2)^2}{2n}$; n = number of sample.

Measurement of CFT

Dental models of each subject for maxillary and mandibular arches were scanned via Hirox digital stereomicroscope (HIROX KH7700, Japan) for the fabrication of the digital models. CFT were carried out via stereomicroscope (SM) scanned digital models for maxillary and mandibular arches (Figs. 2 and 3). SM was proven as valid¹⁹⁾ and reliable tool for such measurements with the accuracy of 0.1×10^{-6} mm.

Statistical analysis

Data collected by the investigators were first entered into Excel (Microsoft, Redmond, Washington, USA). Collected data were screened for any missing values or outliers and for validity of distribution assumptions. To summarize the data, means and standard deviations of CFT were calculated. An independent samples t-test was used to evaluate differences for CFT in males and females. The paired sample t test was used to determine differences in teeth size between the right and left side of the maxillary and mandibular arches. A P value ≤ 0.05 was considered to be statistically significant. All statistical analyses were performed in SPSS (IBM SPSS Statistics Version 22.0, Chicago, USA).

Results

Error of the method

The method error was analyzed by the Dahlberg's double determination formula, showed the value of 0.973mm for CFT. The combined error for any of the variables was small and considered to be within acceptable limit³¹⁾.

CFT norms and inter sex disparities

Table 1 shows CFT comparisons between males and females using stereomicroscopic digital models. The developed norms for the CFT, demonstrated with significantly greater values for males in relation to females. More precisely, there were statistically significant differences observed in different variables (* $p \leq 0.05$ to *** $p \leq 0.001$).

CFT comparison sides disparities for the maxillary and mandibular teeth

Table 2 shows disparities between the right and left side for the CFT maxillary and mandibular teeth size. There were no statistically significant differences observed in all variables.

CAR and COR ratio and inter sex disparities

Table 3 shows CAR and COR ratio norms with slight greater value for males without any statistically significant differences.

Discussion

In orthodontic diagnosis and treatment planning, the evaluation of the tooth size and tooth size discrepancy is an indispensable step and this investigation is generally determined by study model analysis. To evaluate this relationship, various linear measurements by sliding calipers and digital models have been used^{3,14,16-19)}. Digital dental models were considered as a valid and reliable tool for different tooth size measurements^{17,19,20,32)}. Tooth size measurements were done with the accuracy of 1×10^{-2} mm using digital caliper on the plaster models, emodels, and anatomodels and suresmile software with 0.1 mm³³⁾ the current study SM digital models is with the accuracy of 0.1×10^{-6} mm which is a valid tool¹⁹⁾.

The most popular parameter for assessing the tooth size and

tooth size discrepancy remains the mesiodistal tooth width, but it is affected by various factors and can often be misleading. When using the mesiodistal tooth width, factors such as the patient's age, attrition and time consumption, which makes the interpretation of this tooth size and tooth size discrepancy much more complex. To overcome these problems, investigator measured the tooth size via mesiodistal^{1,12)}, buccolingual³⁴⁾ and diagonal crown diameters³⁵⁾. Current study investigated the tooth size via CFT to assess the tooth size via alternate method. Tooth size may assume an imperative part in the etiology of malocclusions, should be considered for various analyses in orthodontic examination and treatment⁵⁾. Thus CFT is the alternate way to measure the tooth size from different perspective to help in the examination and treatment planning. The proposed CFT values will be of great importance in orthodontics for the ideal treatment to finish with proper interdigitation, overbite and overjet.

Nature has given a perfect proportion for teeth to occlude in proper relation. These relations were explored by means of mesial distal tooth estimate by Bolton^{24,25)}. In orthodontic diagnosis and treatment planning tooth size ratio is of extreme value. Some studies reflect that various tooth-size ratios show indigenous and sex differences^{1,8)}. Others found no significant differences in either anterior or overall ratios in subjects with different malocclusion^{27,28)}. Investigator in addition offered the newest formula for tooth size discrepancy³⁶⁾. Current study investigated the tooth size ratio via CFT for CAR and COR which is an alternate novel method to assess the tooth size discrepancy in orthodontics. CAR and COR showed no significant differences in relation to gender. In reality, without perfect proportional relationships in the circumferential tooth size, we cannot give ideal occlusion to the patients at the finishing stage of orthodontics treatment.

Human teeth have lots of variations in size in relation to race and sex^{37,38)}. Tooth size disproportion is the lack of accord between the intermaxillary tooth size or group of teeth. Any disharmony in the tooth size can lead to either spacing in one arch or effect the functional relationship. To achieve an ideal occlusion the teeth size should be in ideal relation from all dimensions, such as mesiodistal, buccolingual and diagonal tooth size. The CFT cover the tooth size in all dimensional aspects. Thus for the accomplishment of good occlusion with the accurate overbite and overjet, the maxillary and mandibular teeth must be proportional in size form all dimensional aspects. For the prediction of ideal occlusion to be achieved at the finishing stage, orthodontist needs to evaluate CAR and COR ratios via proposed method. Current study investigated the tooth size and tooth size discrepancies for both sexes.

CFT, CAR and COR norms will be of great value in forensic dentistry and dental anthropology investigations in addition to orthodontic treatment planning. CFT, CAR and COR need to be further investigated on other population for sexual dimorphism.

In conclusion the, norms were developed for CFT using stereomicroscopic digital models; there is no difference between the CFT of right and left side of the maxillary and mandibular arches; norms were developed for the CAR and COR ratio to assess tooth size discrepancy; CFT presented the sexual dimorphism with the greatest value for male were observed; the developed norms CAR and COR ratios will be helpful adjunct in orthodontic treatment planning for understanding the tooth size discrepancies.

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