Research Journal of Recent Sciences ISSN 2277-2502
Vol. 3(**IVC-2014**), 85-94 (**2014**) *Res. J. Recent. Sci.*

Tooth size and Dental arch Dimension measurement through Cone beam Computed Tomography: Effect of Age and Gender

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Available online at: www.isca.in, www.isca.me
Received 1st July 2014, revised 4th August 2014, accepted 24th September 2014

Abstract

Objective of the study is to inspect the tooth size and arch dimension by the assistance of 3D cone beam computerised tomography (CBCT) imaging through the effect age and gender differences. Data from fifty-three subject were examined; of which 32 were male the ages of the samples were similar in both sexes. The data source was 3D CBCT volumetric data from the archives of the School of Dental Sciences, HUSM. The tooth size (mesio-distal width), arch length, arch perimeter, inter-canine, inter-first premolar, inter-second premolar and inter-molar widths were measured and recorded from the 3D CBCT of both maxilla and mandibular arches. Gender differences and changes associated with age were assessed. Regression analyses were used to examine the influence of age and gender on the tooth size and arch perimeters. Principal component analysis was carried out for the measurements of each arch in males and females samples. The tooth size of the right and left side were similar in the sample except the second premolars where the right side tooth were significantly larger than its counterpart (p=0.007) but with smaller differences (0.2mm to 0.08mm). Largest variation in the tooth size were found in the upper lateral, second premolars and lower lateral incisors in men whereas the upper canine and lower incisors in the women. Tooth size of the upper and lower canine showed the largest variation of sexual dimorphism. For the Arch dimension, the greatest variation was found in the inter-second premolar width of the upper arch followed by inter canine distance, and the inter-canine distance of the lower arch.

Keywords: 3D, CBCT, tooth size, sexual dimorphism, arch dimension.

Introduction

Development of CBCT that provides 3D digitalize image for the orthodontics diagnosis is a major achievement in the late 1990s. CBCT is used in various clinical settings for observing maxillofacial region. CBCT provides high quality images in short time and with a lesser amount of radiation than conventional CT. CBCT also provides more precise and accurate 3D information of the orofacial structures than 2D radiographs[1].

Record keeping and imaging in orthodontic has come a long way since the "Plaster era" when the plaster model was the recording medium for the dentitions and as well as the facial form. Modernization, development and new evaluations in the technology lead the subject of orthodontics to the "filmera". The era in which the orthodontic practice is now is called the period of "digital era" in which the digital technologies are being used to resolve the previous limitation of the patient record keeping and management[2].

CBCT 3D digital image can be used to appraise developing arch length discrepancies. Sizes of both erupted and un-erupted teeth as well as the arch length obtainable can be investigated and the suitable timing of an orthodontic course of action can be decided by the practitioner[3].

With the support of CBCT, orthodontist can make and work on the digital diagnostic simulation models (DDS) by the scanning the dental cast or direct in vivo. These CBCT acquisitions can be for the 3D picturing and measurement; such as the tooth size discrepancies, arch length dimension problem diagnosis. All these function can be performed with help of software's[2].

CBCT allows to, determine tooth size and arch dimension as quickly, reliably, accurately, and reproducibly matched with dimensions (measurement) obtained using the Digital Method on digitalized plaster models. There are no clinical differences between measurements using the CBCT method and those using the Digital Method (2D)[1].

Determination of arch form is vital in clinical orthodontics for esthetics and for long-term occlusal stability through the maintenance of the original mandibular inter-canine width and preservation of the original arch form[4]. There are some basic differences in dental arch size and shape between the different populations[5]. Studies of other populations have further supported these findings[6]. For the orthodontic treatment planning and diagnosis the dental arches, its dimension has a great importance for the position of teeth, smile, esthetics, stability of teeth and dental arches (Noor and Ausama, 2011).

Tooth size and arch dimension analysis direct measurement methods including hand-held calipers, graphs and scale to record dimensions and tooth size on dental casts have been used[7]. Recent development in technology has made it possible that the dental cast can be produced in three-dimension[7, 8]. These digital model studies provide more accurate and reliable tools for obtaining measurements and carrying out dental analysis[6]. Moreover, they have additional benefits, such as accessibility of the images produced, reduction in storage costs and the ability to analyze images by using sophisticated software[6,9].

There are relatively few 3D studies of tooth size and dental arch dimensions[10]. 3D images acquisition, using the stereophotogrammetric method has great authenticity and reliability for the arch dimension, mesio-distal width of the tooth size[11]. CBCT system of 3D digital acquisition can be used in various dental sections such as orthodontics, endodontic, implantology, surgery and oral diagnosis, among others. Though, in instruction to regulate the paramount application of CBCT in dental subjects and specialties, it is essential to investigate tooth length and arch dimension measurements for the different population. The prime aim of this study is to evaluate the tooth size and dental arch measurement by in vivo 3D CBCT.

Material and Methods

All participants provide their written informed consent prior CBCT, and this study was approved by the Ethical Committee of the Hospital UniversitiSains Malaysia (HUSM), which complies with the Declaration of Helsinki. This study was designed and conducted according to the guidelines of strengthening the Reporting of Observational studies in Epidemiology (STROBE), and we applied the STROBE checklist in the preparation of this manuscript[12].

The data source was CBCT volumetric data from the archives of the School of Dental Sciences, HUSM. Tooth size , arch length ,arch perimeter, inter-canine, inter-first premolar, inter-second premolar and inter-molar widths were measured and recorded in 53 3D CBCT volumetric data (32 male and 21 female), both in maxilla and mandibular arches .

Inclusion criteria: i. Age between 16 to 35 years, ii. Full dentition in both maxilla and mandibular arches excluding the third molars, iii. High quality CBCT volumetric data, iv. Ethnicity verified from the folder.

Exclusion criteria: Severe crowding, Excessive spacing, Radiographic evidence of pathology within the maxilla or mandible, Periodontal disease, Retained deciduous teeth, Fixed orthodontic appliance, Inter proximal caries or restoration, Missing or supernumerary teeth, Abnormal size or morphology of teeth, Tooth wear to the extent of impairment the contact point, Damage or extorted CBCT 3D acquisitions.

The CBCT data were acquired using Plameca Promax 3D (Helsinki, Finland). Plameca Romexis software was used to produce a secondary reconstruction of the volumetric data. Transaxial and sagittal slices (1 mm) were generated in the selected maxilla or mandibular images. Identical conditions were used for the measurement of the images throughout the study.

Measurement on CBCT digital image: The linear measurements were made for tooth size, arch length, arch perimeter, inter-canine, inter-first premolar, inter-second premolar and inter-molar widths explain as follows - showed in figure-1 and figure-2.

Measurement of error: Calculations were made for 12 images that were randomly selected. The calculations were repeated again two weeks later. These calculations were performed to assess the systemic and random errors. Systemic errors were measured using a two-sample t-test for each pair of readings. Houston mentioned that there would be no systemic bias if the p value is greater than 0.1[13]. Random errors were estimated by calculating the correlation between repeated measurements (index of reliability). Stirrup mentioned that a correlation value greater than 0.95 is acceptable [14]. All test and retest measurements showed an intra-class correlation of greater than 0.96. These results showed that there were no random errors. All pairs of measurements showed a p value of greater than 0.1, which confirmed that there was no systemic bias in these readings.

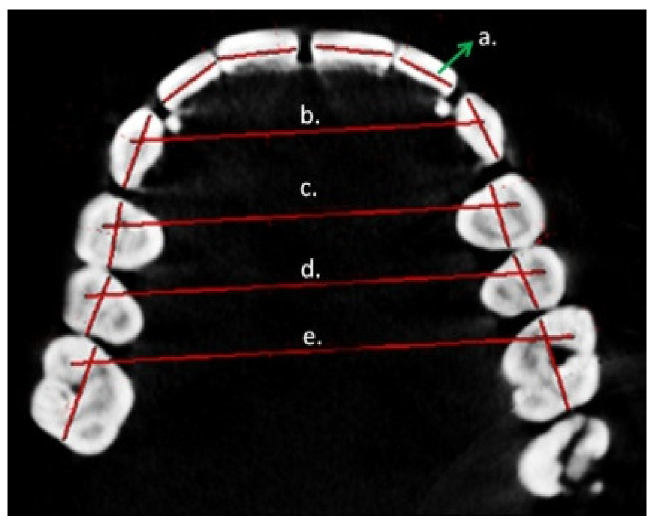

Figure-1
Tooth size and arch dimensions.a. Tooth size: is the mesio-distal width which resembles to the maximum distance across the anatomic contact point of teeth for the maxillary and mandibular teeth. Malposed tooth is measured through imaginary contact point of the proximal area. b. Inter canine width: is measured form the cusp tip of one side to the contrary side cusp tip, for the wear canines the midpoint of the wear facets were manifest as an orientation in the upper and lower arch. c and d. Inter premolar widths: the points on the 1st and 2nd premolar were marked from the buccal cusp tip to the buccal cusp tip of the contralateral side in both arches. e. Inter molar width: were taken from the mesio-bucal cusp tip of right side to the left side for both arches.

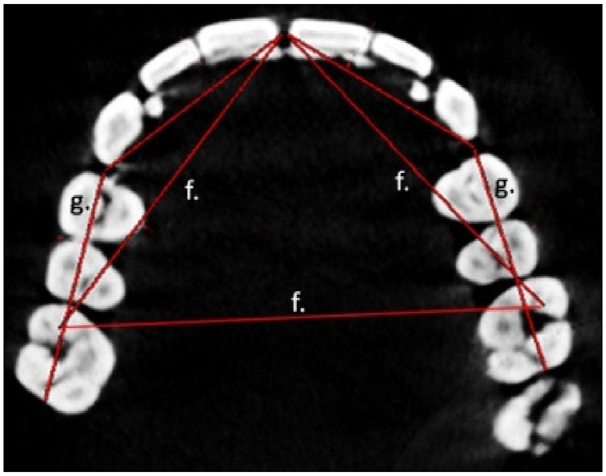

Figure-2
Arch perimeter and arch length.f. Arch perimeter: Transverse line connecting between three points as from the mesio-bucal cusp tip to the mesio-bucal cusp tip of the opposite side and the line then protracted from both side anteriorly to the centre point between the central incisors. g. Arch length: The sum of fragmental lines from right and left side of the arch. (These segments are starting from the distal contact of the molar to the mesialcontact point of the canine and after here to the contact point of the central incisors).

Statistical Analysis: All the measurements was introduced to the Excel spreadsheet and the data were statistically analysed using SPSS version 20 (Chicago, USA). P-values less than 0.05 were considered to be statistically significant. Regression analysis was used to examine the influence of age and gender on the tooth size and dental arch dimensions. For the principal component analysis result from the orthogonal rotation were reported.

Results and Discussion

Right and left comparison: The mesio distal width of the right and left side were similar in the sample except the second premolars where the right side tooth were significantly larger than its counterpart (p=0.007) but with smaller differences (0.2mm, 0.08mm) thus the following statistical analysis were carried for the right side. Descriptive statistics including the mean values, Mean (SD), coefficients of variation (CV) and dimorphism percent for mesio-distal crown widths and dental arch dimensions in men and women were determined table-1 Only 15 was found to be statistically significantly larger than 25 (p=0.007). But differences is small (0.2mm, se 0.08) not significant when analysed for each sex.

Gender and age comparisons: The ages of the samples were similar in both sexes. Largest variation in the tooth size were found in the upper lateral, second premolars and lower lateral incisors in men whereas the upper canine and lower incisors in the women Table-1. For the arch dimension largest variations were found in the upper and lower inter canine length in males and upper inter canine and inter molar width in the females. Tooth size of the upper and lower canine showed the largest variation of sexual dimorphism Table-1. For the Arch dimension, the greatest variation was found in the inter-second premolar width of the upper arch followed by inter canine distance, and the inter-canine distance of the lower arch. No variation found in the arch dimensions in samples from different age groups. There is no trend in the dimension of the arches with increasing age in both sexes table-2,3. Result for the analysis of the influence of age and sex on the dental arch dimension and tooth size, two-way analysis of variance /regression were used. The tooth sizes of the upper and lower canines were statistically differentbetween the sexes table-4. Data also suggested that the tooth sizes of the upper molar and lower canines were influenced by the age.

Principle component analysis (Estimation Sample): Principal component analysis was carried out for the measurement of each arch in males and females samples. In the men, two components were extracted for the upper arch which suggest interdependency of inter-molar, inter first premolar and inter second premolar distances in the first component; and the sizes of the teeth first molar, canine, lateral incisors and central incisors in the second component table-5.

The result suggest that the dimension from the premolar to the molar region are somewhat related plausibly influence each other positively; meaning that either the inter-molar distance determined the corresponding dimension of the premolar region or vice versa. Equivalently, the anterior teeth that formed the second component have no impact on the arch dimension in normal occlusion subject.

Three components were extracted from the lower arch of male samples. Interestingly, the first component suggested that lower premolar teeth were related to the arch perimeters and arch length. The second and third components were by similar parameters in the component 1 and 2 of the upper arch.

In the females three component were extracted in the upper arch measurement table-6. The first component which was formed by the premolar and molar distances, the arch length and arch perimeters; and it is consistent with the fact that the latter two dimensions increases as the mid maxillary regions widens. The second was formed by all teeth except the canines; which, together with inter canine distance form the third component. PCA on the lower arches measurement in female samples resulted two components. The first were formed by measurement that was consistent with the upper arch except arch perimeters and the second were formed by the mid arch teeth.

Discussion: According to Houston, the most important contributions to the improvement of landmark identification are experience and calibration[13]. Therefore, the author performed periodic calibrations with a different set of CBCT images with one of the supervisors. Only one experienced radiographer was responsible for taking the images in the same position as specified by the manufacturer of the radiographic equipment.

Table-1
Mean (SD), coefficients of variation (CV) and dimorphism per cent for mesio-distal crown widths dental and arch dimensions in men and women

Tooth number	Male (mean, SD) n= 32	CV	Female (mean, SD) n= 21	CV	Dimorphism
16	10.0 (0.61)	6.1	9.7 (0.70)	7.2	3.1
15	6.7 (0.56)	8.4	6.7 (0.54)	8.0	0.0
14	6.8 (0.61)	9.0	6.7 (0.66)	9.9	1.5
13*	7.4 (0.60)	8.1	6.9 (0.85)	12.3	7.2
12	6.3 (0.69)	10.8	6.2 (0.36)	5.8	1.6
11	7.8 (0.63)	8.1	7.8 (0.53)	6.9	0.0
21	7.8 (0.70)	9.0	7.6 (0.53)	7.0	2.6
22	6.3 (0.67)	10.7	6.2 (0.56)	9.0	1.6
23	7.2 (0.60)	8.3	6.9 (0.71)	10.3	4.3
24*	6.9 (0.56)	8.1	6.6 (0.62)	9.5	4.5
25	6.5 (0.55)	8.5	6.5 (0.77)	11.9	0.0
26	10.1 (0.74)	7.3	9.7 (0.90)	9.3	4.1
36	11.1 (0.86)	7.8	10.8 (0.70)	6.5	2.8
35	7.2 (0.67)	9.3	6.9 (6.74)	10.8	4.3
34*	6.9 (0.49)	7.1	6.5 (0.62)	9.5	6.2
33*	6.5 (0.63)	9.7	6.0 (0.54)	9.1	8.3
32	5.2 (0.53)	10.2	5.2 (0.53)	10.1	0.0
31	4.7 (0.45)	9.5	5.1 (0.69)	13.7	-7.8
41	4.8 (0.47)	10.0	5.0 (0.67)	13.6	-4.0
42	5.2 (0.60)	11.4	5.2 (0.57)	10.9	0.0
43*	6.6 (0.52)	7.9	6.1 (0.63)	10.3	8.2
44	7.0 (0.56)	8.0	6.8 (0.60)	8.9	2.9
45	7.4 (0.87)	11.7	7.1 (0.57)	8.1	4.2
46	11.1 (0.73)	6.5	10.8 (0.66)	6.1	2.8
Archdimensions					
I-canineU*	36.6 (2.47)	6.7	34.3 (3.29)	9.6	6.7
I-canineL**	29.7 (3.86)	13.0	27.7 (2.07)	7.5	7.2
I-prem1U*	44.3 (2.77)	6.2	42.0 (3.24)	7.7	5.5
I-prem1L*	38.0 (2.91)	7.7	36.0 (2.26)	6.3	5.6
I-prem2U*	49.4 (3.22)	6.5	45.8 (3.90)	8.5	7.9
I-prem2L	43.4 (4.07)	9.4	41.4 (5.64)	13.6	4.8
I-MU*	52.7 (2.81)	5.3	50.1 (3.33)	6.7	5.2
I-ML	48.0 (4.78)	10.0	47.0 (7.46)	15.9	2.1
ALU	77.4 (5.74)	7.4	74.5 (4.47)	6.0	3.9
ALL	69.0 (5.00)	7.2	66.9 (7.12)	10.7	3.1
APU	93.1 (6.84)	7.4	90.8 (4.80)	5.3	2.5
APL	86.9 (5.92)	6.8	84.1 (5.03)	6.0	3.3

I-canineU (Inter canine width Upper Arch), I-canineL (Inter canine width Lower Arch), I-prem1U (Inter 1st Premolar width Upper Arch), I-prem2U(Inter 2nd Premolar width Upper Arch), I-prem1L (Inter 1st Premolar width lower Arch), I-prem2L (Inter 2nd Premolar width lower Arch), I-MU(Inter Molar Upper arch), I-ML(Inter Molar Lower Arch),ALU(Arch Length Upper), ALL (Arch Length Lower Arch), APU (Arch Perimeter Upper Arch), APL(Arch Perimeter lower Arch).

Table-2
Mean (SD) for mesio-distal crown widths and dental arch dimensions across the age groups in men

Tooth Number	12-14 (n=3)		15-17 (n=6)		>18 (n=23)	
	Mean	SD	Mean	SD	Mean	SD
16	10.7	0.1	10.1	0.43	9.9	0.64
15	7.2	0.46	6.4	0.69	6.7	0.52
14	7.2	0.56	6.5	0.73	6.8	0.57
13	8.1	0.15	7.3	0.66	7.4	0.58
12	6.7	0.64	6.8	0.50	6.2	0.68
11	8.5	0.70	7.9	0.53	7.7	0.61
21	8.5	0.55	7.9	0.38	7.6	0.73
22	6.4	0.40	6.3	0.55	6.2	0.74
23	8.0	0.31	6.9	0.50	7.2	0.56
24	7.4	0.50	6.9	0.95	6.9	0.42
25	7.3	0.12	6.6	0.76	6.4	0.46
26	10.6	0.35	10.4	0.65	10.0	0.77
36	11.7	0.21	11.5	0.76	10.9	0.88
35	7.7	0.56	7.4	0.64	7.1	0.68
34	7.3	0.06	7.0	0.52	6.8	0.48
33	7.4	0.55	6.5	0.53	6.4	0.58
32	5.1	0.80	5.4	0.34	5.2	0.55
31	4.5	0.46	4.9	0.23	4.7	0.49
41	5.0	0.7	4.9	0.36	4.7	0.48
42	5.2	0.85	5.4	0.39	5.2	0.63
43	7.3	0.30	6.4	0.32	6.5	0.51
44	7.4	0.23	6.8	0.52	7.0	0.59
45	7.5	0.36	7.4	0.63	7.4	0.98
46	12.0	0.38	11.3	0.64	11.0	0.72
Archdimension						
I-canineU	36.9	3.39	36.8	2.33	36.6	2.51
I-canineL	29.3	1.93	29.4	3.37	29.8	4.25
I-prem1U	44.5	3.02	44.5	1.65	44.2	3.05
I-prem1L	38.8	3.10	38.3	2.82	37.8	3.02
I-prem2U	47.1	1.93	49.7	1.43	49.6	3.61
I-prem2L	43.2	4.3	44.5	2.87	43.2	4.42
I-MU	50.1	1.47	53.7	1.47	52.7	3.04
I-ML	47.2	3.07	48.5	1.84	48.0	5.52
ALU	74.9	5.22	81.0	3.56	76.8	6.03
ALL	67.8	5.18	72.5	5.16	68.2	4.76
APU	91.7	6.02	97.5	4.99	92.1	7.10
APL	86.9	6.51	92.4	5.74	85.5	5.26

I-canineU (Inter canine width Upper Arch), I-canineL (Inter canine width Lower Arch), I-prem1U (Inter 1st Premolar width Upper Arch), I-prem2U(Inter 2nd Premolar width Upper Arch), I-prem1L (Inter 1st Premolar width lower Arch), I-prem2L (Inter 2nd Premolar width lower Arch), I-MU(Inter Molar Upper arch), I-ML(Inter Molar Lower Arch), ALU(Arch Length Upper), ALL (Arch Length Lower Arch), APU (Arch Perimeter Upper Arch), APL(Arch Perimeter lower Arch).

Table-3
Mean (SD) for mesio-distal crown widths and dental arch dimensions across the age groups inwomen.

Tooth Number	**12-14 (n=2)**		**15-17 (n=4)**		**>18 (n=15)**	
	Mean	**SD**	**Mean**	**sD**	**Mean**	**Sd**
16	10.2	0.99	10.2	0.57	9.6	0.67
15	7.3	0.71	7.0	0.33	6.6	0.50
14	6.8	0.57	6.7	0.56	6.6	0.72
13	6.4	1.27	6.4	1.18	7.1	0.67
12	6.7	0.49	6.1	0.41	6.2	0.32
11	7.8	0.28	8.0	0.34	7.7	0.60
21	7.3	0.14	7.6	0.58	7.6	0.56
22	6.4	0.28	6.0	0.62	6.2	0.59
23	7.0	0.78	6.0	0.37	7.1	0.61
24	6.3	0.57	6.5	1.0	6.6	0.55
25	7.1	0.64	6.9	0.46	6.2	0.78
26	9.7	0.42	10.3	0.69	9.6	0.97
36	11.4	0.21	10.9	0.59	10.8	0.77
35	7.1	0.57	6.7	0.53	6.9	0.82
34	6.4	1.20	6.7	0.22	6.5	0.66
33	6.1	0.42	6.0	0.57	6.0	0.58
32	5.5	0.28	4.8	0.52	5.3	0.50
31	4.9	0.14	4.7	0.57	5.2	0.74
41	5.2	0.35	4.5	0.62	5.1	0.68
42	5.5	0.64	4.9	0.46	5.3	0.59
43	6.5	0.21	6.2	0.54	6.0	0.68
44	6.7	0.28	7.1	0.67	6.7	0.61
45	7.5	0.07	7.2	0.31	7.0	0.65
46	11.2	0.64	11.0	0.53	10.7	0.71
ArchDimensions						
I-canineU	35.5	1.56	32.1	0.69	34.7	3.66
I-canineL	28.3	1.06	26.4	1.44	27.9	2.23
I-prem1U	42.8	0.49	40.0	2.91	42.4	3.43
I-prem1L	37.5	1.70	34.4	1.38	36.2	2.36
I-prem2U	41.7	5.73	43.9	4.30	46.8	3.29
I-prem2L	41.0	4.74	40.0	5.12	41.9	6.11
I-MU	49.9	4.10	48.3	3.35	50.6	3.31
I-ML	45.0	6.08	45.0	4.33	47.8	8.39
ALU	73.6	4.45	74.4	4.91	74.7	4.67
ALL	65.1	6.72	64.1	3.38	67.9	7.94
APU	90.7	4.17	89.9	3.26	9.1	5.39
APL	84.7	5.30	83.3	3.87	84.2	5.54

I-canineU (Inter canine width Upper Arch), I-canineL (Inter canine width Lower Arch), I-prem1U (Inter 1st Premolar width Upper Arch), I-prem2U(Inter 2nd Premolar width Upper Arch), I-prem1L (Inter 1st Premolar width lower Arch), I-prem2L (Inter 2nd Premolar width lower Arch), I-MU(Inter Molar Upper arch), I-ML(Inter Molar Lower Arch),ALU(Arch Length Upper), ALL (Arch Length Lower Arch), APU (Arch Perimeter Upper Arch), APL(Arch Perimeter lower Arch).

Table-4
Result for analysis of the influence of age and sex on dental arch dimensions and mesio-distal crown widths using two-way analysis of variance / regression.

Tooth Number	Sex		Age		Age*sex	
	F statistic	p-value	F statistic	p-value	F statistic	p-value
16	2.9	0.1	3.6	0.04	0.6	0.6
15	0.0	0.9	2.4	0.1	2.0	0.1
14	0.4	0.5	1.0	0.4	0.6	0.5
13	8.1	0.006	1.2	0.3	2.8	0.07
12	0.5	0.5	3.0	0.6	1.6	0.2
11	0.1	0.7	2.1	0.1	0.8	0.5
41	1.6	0.2	0.7	0.5	1.8	0.2
42	0.1	0.8	0.04	0.96	0.9	0.4
43	10.0	0.0027	3.3	0.0456	0.8	0.4
44	1.9	0.2	0.5	0.6	1.3	0.3
45	2.7	0.1	0.2	0.8	0.1	0.9
46	3.3	0.08	3.0	0.06	0.3	0.7
I-canineU	8.5	0.005	0.5	0.6	1.0	0.4
I-canineL	4.7	0.036	0.3	0.8	0.2	0.9
I-prem1U	7.8	0.0075	0.4	0.7	0.8	0.5
I-prem1L	7.2	0.0102	0.5	0.6	0.7	0.5
I-prem2U	14.2	0.0004	2.6	0.09	1.0	0.4
I-prem2L	2.2	0.1	0.02	0.985	0.4	0.7
I-MU	8.9	0.0044	0.8	0.4	1.6	0.2
I-ML	0.3	0.6	0.2	0.8	0.3	0.7
ALU	3.8	0.06	1.2	0.3	0.7	0.5
ALL	1.6	0.3	0.3	0.8	1.8	0.2
APU	1.7	0.2	0.9	0.4	1.2	0.3
APL	3.5	0.08	1.9	0.2	2.0	0.1

I-canineU (Inter canine width Upper Arch), I-canineL (Inter canine width Lower Arch), I-prem1U (Inter 1st Premolar width Upper Arch), I-prem2U(Inter 2nd Premolar width Upper Arch), I-prem1L (Inter 1st Premolar width lower Arch), I-prem2L (Inter 2nd Premolar width lower Arch), I-MU(Inter Molar Upper arch), I-ML(Inter Molar Lower Arch),ALU(Arch Length Upper), ALL (Arch Length Lower Arch), APU (Arch Perimeter Upper Arch), APL(Arch Perimeter lower Arch).

The 3D models gained from the CBCT are as precise and replicable as the digital models achieved from the plaster study casts for calculating the tooth size and discrepancies. The variances present among both approaches were clinically satisfactory[15]. Before conducting different orthodontic measurement for the tooth size and arch dimension there must be a data for the tooth size for that relevant ethnic, gender and numerous malocclusion assembly[10, 16]. The data norms available for the population will be helpful in the forensic odontology and orthodontic treatment designs[16].

The study was undertaken on patients who compared the CBCTs of 30 patients using the InVivo Dental program and the digital models obtained by OrthoCad; no statistically significant differences between them being found for tooth measurements. CBCT digital models are as accurate as OrthoCAD digital models in making linear measurements for overjet, overbite, and crowding measurements[17]. In this study, we analyzed 53 maxilla and 53 mandibles. The sample size was comparatively much higher than the study conducted via CBCT[1].

Our study showed that the tooth size of right and left side were similar except with the second premolar which was larger than its counterpart. This finding was statistically significant (p=0.007) but the difference was very small (0.2mm-0.08mm). Thus the analysis was conducted on the right side. Here it was found that the largest variation in the tooth size were of the upper lateral, second premolars and lower lateral incisors in men whereas the upper canine and lower incisors in the women table-1.Variation of the upper lateral incisors and lower central incisors were consistent with the previous 3d study on the same population[11]. Arch dimension of the upper and lower inter canine length in males and upper intercanine and lower intermolar width in females showed largest variation. Our Methodology is different form the Al-Khatib et al. (2011) they used the camera based imaging system. In Malay population using CBCT for the measurements of safe and danger zone in the maxilla and mandible has been studied for the placement of inter-maxillary fixation screw[18]. We have taken the CBCT for the first time in Malay population to measure tooth size and arch dimensions.

Tooth size of the upper and lower canine also showed the largest variation of sexual dimorphism. For the Arch dimension, the greatest variation was found in the inter-second premolar width of the upper arch followed by inter canine distance, and the inter-canine distance of the lower arch. Similar sexual dimorphism for the canines and upper inter second premolar distance reported[11].For the sexual dimorphism morphological investigations and morph metric differences can be used as helpful signal and believed as a protagonist in forensic science[19]. Tooth size proportion varies, as well as fairly distinct among different ethnic population in relation to their geo graphical location [20, 21].

We measured tooth size and dental arch dimension through the 3D analysis of several measurements for 53 maxilla and 53 mandibles. We did regression analysis as well as PCA. These findings, a using 3D analysis, were obtained from Malay subjects at HUSM. Whether similar findings might be obtained in another population is unknown. Conducting this 3D analysis in study populations from other institutions might be useful.

Table-5
Principle component analysis, estimation of male sample

	Component			
	Men			
	Component 1	**Component 2**	**Component 3**	
UPPER ARCH				
ARCH PERIMETER	0.33		-0.51	
ARCH LENGTH				
INTER MOLAR	0.53	-0.46		
INTER 2nd PR	0.33 [0.49]	-0.36		
INTER 1st PR	0.36 [0.47]	-0.31		
INTER CANINE	0.34			
T16		0.48 [0.48]		
T15			0.59	
T14			0.39	
T13		0.34 [0.43]		
T12		0.41		
T11		0.32 [0.40]		
Eigenvalue	5.14	2.09	1.38	
Cumulative value	30.0	60.2		
LOWER ARCH				
ARCHPERIMETER	0.41 [0.47]			
ARCHLENGTH	0.40 [0.45]			
INTER-MOLAR		-0.56	0.58	
INTER 2nd PR		-0.39	0.37	0.48
INTER 1st PR		0.42	-0.38	
INTER-CANINE		0.55	-0.59	
T46				-0.54
T45	0.32 [0.49]		0.40	
T44	0.38			-0.50
T43		0.51	0.44	
T42		0.49		
T41	0.33	0.58	0.50	
Eigen value	4.1	2.2	1.5	1.4
Cumulative value	0.27	0.47	0.64	

T (Tooth), PR (Premolar).

Table-6
Principle component analysis, estimation of female sample

	Component			
	Women			
	Component 1	**Component 2**	**Component 3**	
UPPER ARCH				
ARCH PERIMETER	0.39 [0.37]			
ARCH LENGTH	0.38 [0.33]			
INTER MOLAR	0.36 [0.47]			
INTER 2ND PR	0.32 [0.52]		-0.44	
INTER1st PR	0.42 [0.43]			
INTER CANINE	0.32		0.41	
T16		0.38 [0.46]		
T15		0.44 [0.40]		
T14		0.36 [0.35]		
T13			0.67 [0.73]	
T12		0.38 [0.46]		
T11		0.40 [0.48]		
Eigen value	4.71	2.73	1.25	
Cumulative value	0.33	0.59	0.72	
LOWER ARCH				
ARCH PERIMETER	0.39			
ARCH LENGTH	0.36 [0.46]			
INTER MOLAR	0.32 [0.51]	-0.42		
INTER 2ND PR	0.35 [0.42]			
INTER 1ST PR	[0.36]		-0.30	0.43
INTER CANINE	0.38		0.71	0.81
T46			-0.41	
T45		0.49 [0.50]		
T44		0.46 [0.51]		
T43		0.41		
T42				
T41				
Eigen value	5.07	1.99	1.33	1.14
Cumulative value	0.33	0.59		

T (Tooth), PR (Premolar).

Conclusion

The conclusion of this study were as follow: i. 3D CBCT imaging allows us to measure the tooth size and arch dimension of when a patient is exposed to CBCT. ii. CBCT can elevate the record keeping problem, tooth size and arch dimension measurements for the analysis can be obtained directly from the digital image. iii. The tooth size of canine showed the greater variation of the sexual dimorphism, larger in males and smaller in females. iv. The current 3D CBCT study provides new values for the tooth size and dental arch dimension of Malays. v. In orthodontic treatment planning, arch dimension measurements can easily be evaluated directly through the 3D CBCT images before expansion of arches. vi. PCA of the male in upper arch suggests that the premolar and molar region are fairly correlated and plausibly affect each other, show interdependency. The extracted component in the lower arch premolar shows the relation to arch perimeter and arch length. vii. PCA of the female sample show consistent measurement to the first component of males maxilla with the exclusion of arch perimeter.

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