Geometric Dental Arch Dimensions in Mixed Dentition Period of Egyptian Children

Abou El-Yazeed, M.[1] and Abou-Zeid, A.W.[2]

[1] Orthodontics and Pediatric Dentistry Department, National Research Centre, Cairo, Egypt.
[2] Oral Biology Department, Misr International University, Cairo, Egypt.
mohamedabouelyazied@yahoo.com

Abstract: Dental arch character is of primary concern to pediatric dentist who occupies pivotal position in providing smooth transition from primary to permanent passing through mixed dentition. **Aim**: This study aims to establish standards for some dental arch dimensions for Egyptian children. **Materials and Methods**: 382 upper and lower dental casts were selected from the records of the dental clinic of the National Research Centre, Egypt for 191 children (122 boys and 69 girls) aged from 6 to 12 years with complete dental string and normal occlusion. Casts were divided into two groups according to the subject's age [Gp. I (6 to < 9.5 years) and Gp. II (9.5 to 12years)]. Casts were scanned and digitized using a digital image tracer. From the digitized reference points certain linear distances were measured to calculate dental arch width, perimeter and depth. **Results**: Almost all maxillary and mandibular arch width for boys was ahead. Significant sex difference in arch perimeter within the second age group where girls were a ahead (P <0.05). Significant difference in arch depth was noticed in the second age group for the upper posterior area where boys were a head (P <0.01) while girls were a head at measurement of lower anterior depth. **Conclusions**: The results throw light on the average dental arch dimensions for Egyptian children throughout the studied age span. That is why clinicians should use the proposed standards for Egyptian children instead of applying standards of other ethnic groups.

[Abou El-Yazeed, M. and Abou-Zeid, A.W. **Geometric Dental Arch Dimensions in Mixed Dentition Period of Egyptian Children.** *Life Sci J* 2013;10(4): 3214-3221]. (ISSN:1097-8135). http://www.lifesciencesite.com. 428

Key Words: Mixed dentition - Dental arch dimensions - Dental cast - Scanning analysis

1. Introduction:

The dental arch dimensions play an important role in determining the alignment of teeth, alleviation of dental crowding and stability of arch form to attain a functional stable occlusion and well balanced facial profile (Prabhakaran *et al.,* 2006). Dento-alveolar development is a complex and continuous biological process throughout the growing period of an individual. As dental arches are in a state of dynamism due to continuous growth and development particularly during the transitional period from primary to permanent dentition which occur systematically in a successional phase (Sangwan *et al.,* 2011), it has been reported that these dimensional changes in the dental arch are genetically determined with environmental influences exerting a minimal effect (Mahesh and Nidhi, 2013). Dental arch character is of primary concern to pediatric dentist who occupies pivotal position in providing smooth transition from primary to permanent passing through mixed dentition (John *et al.,* 2009). It is essential for dental clinicians to recognize the importance of dental arch dimensions to correct malocclusion and get the teeth in their ideal position, in equilibrium with their bony bases (Geran *et al.,* 2006).

Topography of the human dental arch depends on a complex series multifactorial in nature, such as site of specificity, suture expansion, dimension and remodeling of alveolar bone, size and orientation of the teeth, the form of jaws, and the action of the orofacial musculature (Padilla *et al.,* 2013). Various landmarks have been described and discussed by different investigators but still a universal agreement on how dental arch dimensions should be determined has not been reached. Due to a great ethnic diversity, standardization for establishing reference landmarks and techniques should be necessary (Marcia *et al.,* 2011). However, unique dental arch characteristics for each ethnic group is still obscure (Fabiane *et al.,* 2011). Adequate knowledge of normal growth and development of dentition and the expected dimensional changes in the arches by age are important as it is helpful in preventive and interceptive orthodontic procedures. Studies involving mixed dentition period for Egyptian children are relatively scanty; therefore, the present study was carried out to establish normative data of dental arch dimensions for Egyptian children with mixed dentition in both sexes, and in two different age groups.

2. Materials and Methods:

The protocol of this study was first submitted to the ethical committee of the National Research Centre, Egypt. Dental casts were taken from 191 children (122 boys and 69 girls) aged from 6 to 12 years with normal occlusion, having a complete dental string without premature loss of teeth or absence of any obvious loss for tooth materials. These casts selected from the archive of dental clinic in the National Research Centre. The dental casts sample inclusion criteria was

as follow: no evidence of bubbles or damaged casts or lost material that make data measurements are questionable. The distribution of dental casts in both arches by sex and age groups is presented in table 1.

Dental models were scanned and digitized using a digital image tracer especially designed for dental research works (Dental tracer[(c)], Nile Delta for software, version II).

The reference points and planes (appendix 1) were found and digitally marked by a senior investigator and checked by another to verify the accuracy of landmark placement (Fig. 1).

Table (1): Distribution of dental casts (upper and lower) by sex and age group

Sex / Age groups	Boys	Girls	Total
I (6.0 < 9.5 years)	109	56	165
II (9.50 - 12 years)	135	82	217
Total	244	138	382

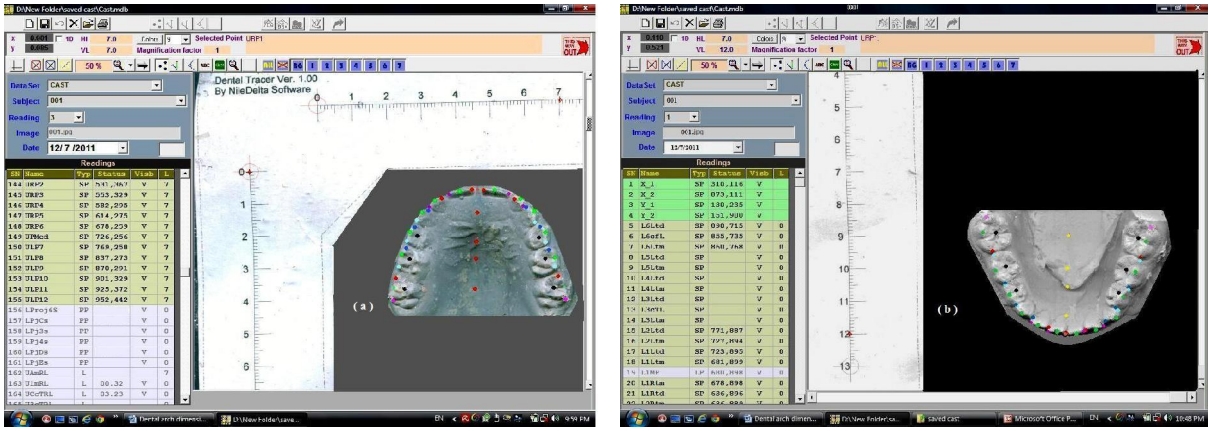

Figure 1: Reference points of a scanned upper (a) and lower (b) casts of a male child

Dental cast measurements:

From the reference points and landmarks of the scanned upper and lower casts which were digitized, the linear distances (width, perimeter and depth) were calculated (Fig. 2, 3 and 4).

Arch width:

Anterior arch width was measured as a horizontal distance (cm) between the cusp tips of the right and left deciduous canines (C-C) or permanent canines (3-3).

Middle arch width was measured as a horizontal distance (cm) between right and left central fossae of deciduous first molars/first premolars, deciduous second molars (D-D; 4-4; E-E).

Posterior arch width was measured as a horizontal distance (cm) between central fosse of right first permanent molar to the similar points on the left one (6-6) (Fig. 2).

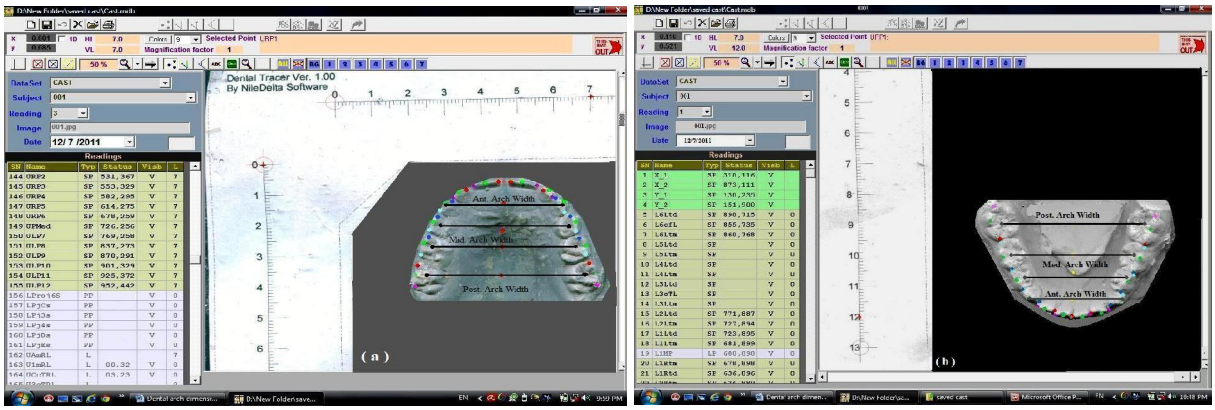

Figure 2: Traced arch widths for upper (a) and lower (b) casts

Dental arch perimeter:

It was determined by constructing a line passing through buccal cusp tips of all posterior deciduous and permanent molars, premolars, deciduous or permanent canines and mid points of incisal edges of the centrals and laterals in both sides (cm) for each upper and lower dental model (Fig.3).

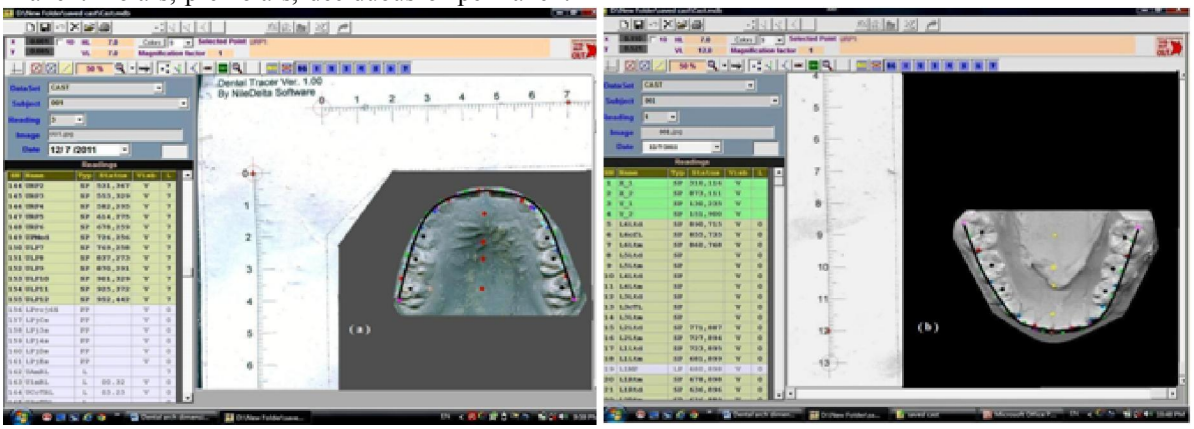

Figure 3: Traced upper (a) and lower (b) dental arch circumferences

Dental arch depth (Length):

It was measured as the distance from a point midway between facial surfaces of the central incisors to a line tangent to the mesial surfaces of the first permanent molars (Fig.4).

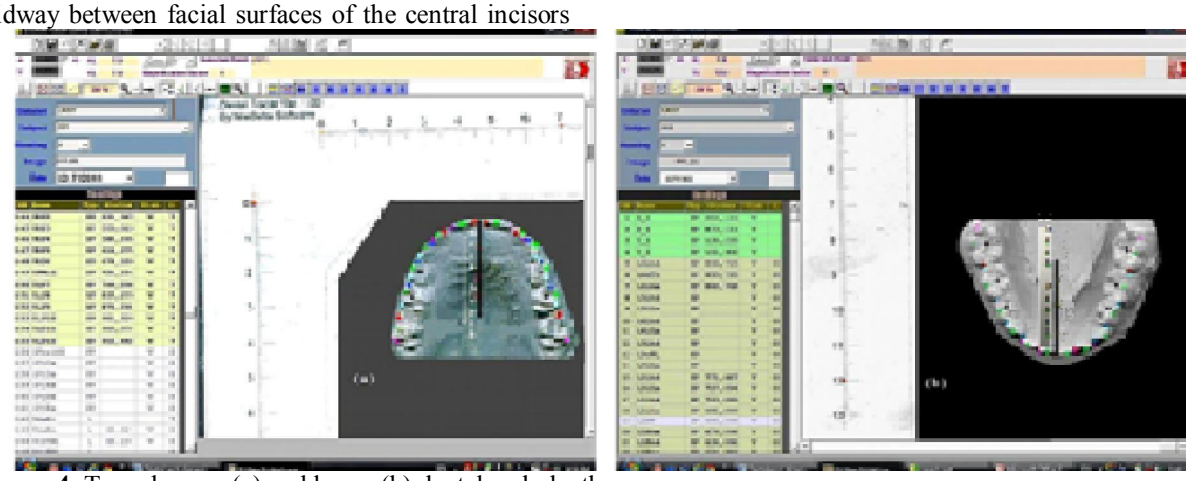

Figure 4: Traced upper (a) and lower (b) dental arch depth

Descriptive statistics were summarized for maxillary and mandibular arches measurements in each sex and age group. Statistical analysis were done using SPSS program version 16 of ULCA (University of California at Los Angeles).

3. Results:

Means and standard deviations of dental arch widths with different dimensions (anterior, middle and posterior) are presented in table (2) for both arches by sex and age groups. For boys, almost all maxillary and mandibular measurements are ahead. Concerning the upper arch, significant sex differences were detected at middle (4-4) and posterior widths (6-6) which were wider in the second age group of boys than girls (4.32 and 4.27cm) versus (4.61 and 4.56). However, girls in the first age group showed significantly wider upper anterior width at the canine area (3-3) than boys (3.41versus 3.37cm) where *p* less than 0.05.

Regarding the lower arch, in both age groups, the only significant sex difference was noticed at permanent molars width areas (posterior arch width 6-6) where boys have wider arches than girls.

Concerning the age differences in both sexes and arches; more or less the second age group dental arch width measurements were slightly wider than the first age group with no significant difference detected.

Table (3) presents means and standard deviations in centimeters of dental arch perimeter by sex and age group; it was obvious that boys in both upper and lower arches follow the same general trend where boys have a longer arch perimeter than that of girls. A significant sex difference was detected for boys (p <0.05) especially at the second age group.

Dental arch perimeter in the second age group were shorter (9.43 and 8.87) than that of the first one (9.68 and 8.98) for girls while in boys they were nearly the same.

Table (4) shows means and standard deviations of arch depth in both sexes for each age group. It was noticed that in the second age group, the depth of the arch till the upper second deciduous molar distance (U1EE), and upper first premolars (U144) as well as first permanent molar (U166) for boys are significantly longer than those of girls ($P < 0.05$). Such significant difference unnoticed in the lower arch, the only significant difference noticed was for the distance till the deciduous canines (L1CC) of boys in the first age group which is longer than that of girls ($P < 0.05$).

Table (2): Means and standard deviations of dental arch widths (cm) by sex and age groups

Arch width	Age Group I						Age Group II					
	Boys			Girls			Boys			Girls		
	N	$\overline{X}$	±SD	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD
Upper arch												
C-C	41	3.43	0.23	16	3.35	0.22	35	3.42	0.20	17	3.41	0.32
3-3	8	3.37	0.18	8	3.41*†	0.30	22	3.40	0.22	12	3.52	0.72
D-D	29	4.33	0.24	10	4.26	0.24	16	4.31	0.19	8	4.22	0.57
4-4	9	4.27	0.28	13	4.18	0.31	22	.32*†	0.17	22	4.27	0.70
E-E	32	4.19	0.25	19	4.09	0.25	29	4.20	0.23	18	3.90	0.56
6-6	50	4.57	0.29	25	4.52	0.24	59	.61*†	0.23	36	4.56	0.61
Lower arch												
C-C	36	2.70	0.48	15	2.72	0.26	31	2.76	0.16	16	2.73	0.28
3-3	14	2.69	0.19	5	2.90	0.18	24	2.83	0.31	14	2.80	0.35
D-D	25	3.69	0.19	10	3.64	0.23	22	3.69	0.22	7	3.61	0.26
4-4	1	-	-	1	-	-	8	3.39	1.01	10	3.81	0.48
E-E	10	3.20	1.13	5	3.56	0.25	10	3.23	1.16	8	3.73	0.54
6-6	51	4.09*†	0.22	23	4.03	0.22	61	4.15	0.35	35	4.10*	0.50

* Sig. sex difference at $P < 0.05$ † Sig. age difference at $P < 0.05$

Table (3): Means and standard deviations of dental arch perimeter (cm) by sex and age groups

Arch perimeter	Age Group I						Age Group II					
	Boys			Girls			Boys			Girls		
	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD
Upper arch												
	40	9.79	0.51	20	9.68	0.49	55	9.80*†	0.55	24	9.43*	0.57
Lower arch												
	43	9.11	0.45	20	8.98	0.52	60	9.13*†	0.39	30	8.87	0.55

* Sig. sex difference at $P < 0.05$ † Sig. age difference at $P < 0.05$

Table (4): Means and standard deviations of dental arch depth (cm) by sex and age groups

Arch Depth	Age Group I						Age Group II					
	Boys			Girls			Boys			Girls		
	N	$\overline{X}$	± SD	N	$\overline{X}$	±+ SD	N	$\overline{X}$	± SD	N	$\overline{X}$	± SD
Upper arch												
U_1CC	37	0.79	0.21	14	0.83	0.17	35	0.80	0.19	14	0.76	0.11
$U_1$33	7	0.80	0.14	7	0.78	0.14	22	0.83	0.17	11	0.88	0.14
U_1dd	30	1.75	0.35	9	1.80	0.21	17	1.79	0.29	5	1.59	0.26
$U_1$44	7	1.79	0.21	12	1.66	0.16	23	1.94*	0.43	19	1.75*	0.20
U_1EE	27	2.32	0.27	18	2.28	0.23	29	2.41*	0.22	15	2.17*	0.23
$U_1$66	47	3.16	0.26	21	3.14	0.4	58	3.24*	0.25	31	3.06*	0.32
Lower arch												
L_1CC	28	0.53*	0.09	13	0.46	0.11	29	0.53	0.10	13	0.50	0.10
$L_1$33	12	0.54	0.10	4	0.55	0.64	25	0.56	0.07	12	0.57	0.10
L_1dd	18	1.44	0.13	8	1.51	0.15	20	1.50	0.10	6	1.50	0.21
$L_1$44	-	-	-	1	1.47	0.01	7	1.54	0.12	8	1.44	0.30
L_1EE	9	2.01	0.21	3	1.97	0.07	10	1.93	0.18	7	1.87	0.18
$L_1$66	43	2.94	0.17	20	2.94	0.24	59	2.94	0.20	29	2.85	0.30

* Sig. sex difference at $P < 0.05$

4. Discussion:

Dento-alveolar region undergoes continuous adaptation to compensate the various dimensional age changes particularly during the intensive growth periods. However, these changes do not cease with onset of adulthood but continue at a slower rate (Dager *et al.,* 2008).

The size of the arch depends mainly on the size and position of the teeth, while arch shape depends on the direction of alveolar bone; growth in vertical direction, a variable balance exists between growth in a forward and in a lateral direction. Teeth are positioned in the greatest possible degree of harmony with their bony bases and with the surrounding tissues. Thus presentation of the form and dimension of the dental arches must be one of the first options to attain the ideal occlusion (Fabiane *et al.,* 2011).

During the mixed dentition period, the changes that occur in dental arches are consequences of tooth emergences, movement and growth of supporting bone, besides modest genetic component; these naturally occurring changes have been used for many times as comparative gold standard employed to assist in treatment planning especially in modern dentistry based on prevention and diagnosis of diseases (Maryam *et al.,* 2013).

Arch Width:

According to Mc Donald *et al.* (2005), the average dimensional dental arch changes from 6-18 years for upper arch width bicanines and bimolars increase 5 mm, 4 mm respectively, while circumference increase about 1 mm. and arch length slightly decrease due to the up righting of incisors.

The behavior of these growth changes during the mixed dentition period can be explained by mesial drifting of posterior teeth concomitant with exfoliations of deciduous and eruption of permanent teeth (Chen *et al.,* 2007).

A number of articles have been published reporting sexual dimorphism in dental arch dimension. Regarding the arch widths, the results in this study showed that the boys' arch widths are wider than those of girls (Table 2) where boys are significantly higher at the middle (4-4) and posterior arch (6-6) widths which may be attributed to the complex series of factors e.g. size and shape of the jaw and the action of the oral and facial musculature in addition, the boys have wider teeth mesio-distally (Younes, 1984, Haralabakis *et al.,* 2006 and Ling *et al.,* 2009). On the other hand, maxillary arches are broader than mandibular ones. Also, maxillary alveolar processes are divergent and maxillary molars directed disto-buccally when compared the mandibular alveolar processes which more or less parallel and the inclination of their molars are tilted lingually (Bishara,1997 and Vera *et al.,* 2011).

In this study, there is a significant sex difference in the first age group at the upper (3-3) inter canine width where girls were ahead of boys this may be attributed to the earlier eruption of permanent canine and incisors in girls; this eruption may have a pushing effect on the sutural growth. These results are in agreement with Sillman (1964).

The size of the arch depends mainly on the size and position of the teeth, arch shape depends on the direction of alveolar bone growth. Although there is always growth in a vertical direction, a variable balance exists between growth in forward and lateral direction.

Odajima (1990) and wards *et al.* (2006) in their different longitudinal studies on growth and development of dental arches of primary, mixed and permanent found a gradual increase for the width at the region of the permanent maxillary and mandibular first molars which have reached a stable condition at about 12 years of age. The maximum dental arch breadth appeared to be established prior to the eruption of canines and second bicuspids. Several authors have observed an increase in intercanine and intermolar distances until permanent dentition is completed. The greatest increases take place during the period of greatest growth and decrease slightly from that moment on, especially in the lower intercanine distance (Slaj, 2003; Tibana *et al.,* 2004 and Eslambolchi, 2008). In addition, other author found that the intermolar distance remained stable (Chen *et al.,* 2007).

Arch Perimeter:

The significant greater arch perimeter of the maxilla compared to the mandible in this study reflects the overjet of the maxillary arch which is the outcome of the natural growth of the alveolar processes, sutural growth as well as the size and orientation of the erupting teeth with the alveolar bone, this is in agreement with Bishara *et al.* (1997) and Chen *et al.* (2007) who stated that the behavior of growth during the mixed dentition period can be explained by mesial drifting of posterior teeth concomitant with exfoliation of deciduous and eruption of permanent teeth. The greater perimeter in boys for both arches and in both age groups are due to the fact that boys have wider mesiodistal teeth dimensions which contribute effectively in the final measurement of the dental arch perimeter. A controversial findings in this study was that the perimeter of the second age group as compared to the first age group was almost equal in boys but decreased in girls; this was in agreement with some authors who explained this decrease by the mesial drifting of posterior teeth concomitant with exfoliation of deciduous and eruption of permanent teeth (Conti, 2011). On the contrary many authors have obtained

an increase in arch perimeter until permanent dentition is completed and a diminution of this dimension with age mainly in the lower arch (Slaj *et al.,* 2003; Tibana, 2004 and Dager 2008).

Arch Depth:

It is known that dental arch is divided into various segments like incisor segment, canine segment and molar segment which play a significant role in determining the available space for proper alignment of the permanent dentition in normal occlusion.

The major significant differences between boys and girls in arch depth were at the areas of U1EE, U144, U166 and L1CC where boys are ahead in the second age group; this is in agreement with the longer arch perimeter of boys than girls. The changes in arch depth between boys and girls as well as age groups are controversial; while it increases in the upper arch by age for boys, it is relatively stable in the lower arch and for girls, so it could be noticed that the depth till the canine area increases however it decreases in the posterior segment. The main cause of these changes are believed to be related to the closure of posterior interproximal spaces by replacement of the primary with the permanent dentition and the proximal contacts made by the permanent teeth, this coincides with Thilander *et al.* (2009).

As regards the lower dental arch dimensions in the second age group, the significant differences in the perimeter of the arch despite the absence of difference in any of the depth measurements denotes that the main difference in dimension is in the width of the arch and not in the length, this reflects that growth of the lower jaw depth in both sexes is similar, but males show a relative increase in jaw width.

Conclusion:

The results of the present study throw light on the average dental arch dimensions for Egyptian boys and girls throughout the studied age span. This is why clinicians should avoid thinking of the application of rigid standard for dental arch width, perimeter and depth.

Recommendation

Further longitudinal studies with greater sample size are necessary to follow the dental arch dimensions from the primary to permanent dentition period. Moreover, when drawing up an orthodontic treatment plan, it is important to know the characteristics of the dental arches, namely the arch widths (intercanine and intermolar) and perimeter, and their development over time, as this can provide us with information of the stability or relapse of our treatment.

Corresponding Author:
Abou El-Yazeed, M.
Department of Orthodontics and Pediatric Dentistry
National Research Centre
Dokki –Giza 12311 Egypt
Mailing address: National Research Centre, Dokki – Giza 12622 Egypt
E-mail: mohamedabouelyazied@yahoo.com

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Appendix 1
Definitions of acronyms for the cast landmarks and planes

U/L6(R/L)td	Point on the buccal aspect at the end of the distal marginal ridge of the upper / lower (right/left) first permanent molar
U/L6cF(R/L)	Point on the central fossa of the upper / lower (right/left) first permanent molar
U/L6(R/L)tm	Point on the buccal aspect at the end of the mesial marginal ridge of the lower (right/left) first permanent molar
U/LP$_1$	Point on the tip of the distobuccal cusp of the upper / lower right first permanent molar
U/LE(R/L)td	Point on the buccal aspect at the end of the distal marginal ridge of the upper / lower (right/left) second deciduous molar
U/LEcf(R/L)	Point on the central fossa of the upper / lower (right/left) second deciduous molar
U/LE(R/L)tm	Point on the buccal aspect at the end of the mesial marginal ridge of the lower (right/left) second deciduous molar
U/L5(R/L)td	Point on the buccal aspect at the end of the distal marginal ridge of the upper / lower (right/left) first premolar
U/L5(R/L)tm	Point on the buccal aspect at the end of the mesial marginal ridge of the upper / lower (right/left) first premolar
U/LP$_2$	Point on the tip of the distobuccal cusp of the upper / lower right second deciduous molar / buccal cusp tip of second premolar
U/LD(R/L)td	Point on the buccal aspect at the end of the distal marginal ridge of the upper / lower (right/left) first deciduous molar
U/LDcf(R/L)	Point on the central fossa of the upper / lower (right/left) first deciduous molar
U/LD(R/L)tm	Point on the buccal aspect at the end of the mesial marginal ridge of the upper / lower (right/left) first deciduous molar
U/L4(R/L)td	Point on the buccal aspect at the end of the distal marginal ridge of the upper / lower (right/left) second premolar
U/L4cf(R/L)	Point on the central fossa of the lower (right/left) first premolar

U/L4(R/L)tm	Point on the buccal aspect at the end of the mesial marginal ridge of the upper / lower (right/left) second premolar
U/LP_3	Point on the tip of the mesiobuccal cusp of the upper / lower right first deciduous molar / buccal cusp tip of first premolar
U/Lc(R/L)td	Point on the buccal aspect at the end of the distal cusp slop of the upper / lower (right/left) deciduous canine
U/Lc(R/L)tm	Point on the buccal aspect at the end of the mesial cusp slop of the upper / lower (right/left) deciduous canine
U/L3(R/L)td	Point on the buccal aspect at the end of the distal cusp slop of the upper / lower (right/left) permanent canine
U/L3(R/L)tm	Point on the buccal aspect at the end of the mesial cusp slop of the upper / lower (right/left) permanent canine
U/LP_4	Point on the cusp tip of the upper / lower right deciduous / permanent canine
U/L2(R/L)td	Point on the distoincisal angle of the upper / lower (right/left) permanent lateral incisor
U/L2(R/L)tm	Point on the mesioincisal angle of the upper / lower (right/left) permanent lateral incisor
U/LP_5	Point midway between U/L2Rtd and U/L2Rtm
U/L1(R/L)td	Point on the distoincisal angle of the upper/lower (right/left) permanent central incisor
U/L1(R/L)tm	Point on the mesioincisal angle of the upper/lower (right/left) permanent central incisor
U/LP_6	Point midway between U/L1Rtd and U/L1Rtm
U/L1	A point midway between tow point of U/L1Rtm and U/L1Ltm
U/LLP_7	Point midway between U/L1Ltm and U/L1Ltd
U/LLP_8	Point midway between U/L2Ltm and U/L2Ltd
U/LLP_9	Point on the cusp tip of the upper / lower left deciduous / permanent canine
U/LLP_{10}	Point on the tip of the mesiobuccal cusp of the upper / lower left first deciduous molar / buccal cusp tip of first premolar
U/LLP_{11}	Point on the tip of the distobuccal cusp of the upper / lower left second deciduous molar / buccal cusp tip of second premolar
U/LLP_{12}	Point on the buccal aspect at the end of the distal marginal ridge of the upper/lower left first permanent molar
U/LPjCs	Point midway on a line connecting between two point of U/LRP_4 and U/LLP_9
U/LPj3s	Point midway on a line connecting between two point of U/LRP_4 and U/LLP_9
U/LPjDs	Point midway on a line connecting between two point of U/LRP_3 and U/LLP_{10}
U/LPj4s	Point midway on a line connecting between two point of U/LRP_3 and U/LLP_{10}
U/LPjEs	Point midway on a line connecting between two point of U/LRP_2 and U/LLP_{11}
U/LPj6s	Point midway on a line connecting between two point of U/LRP_1 and U/LLP_{12}
U/L(CC/33)	Line between two points at U/LRP_4 and U/LLP_9
U/L(DD/44)	Line between two points at U/LRP_3 and U/LLP_{10}
U/LEE	Line between two points at U/LRP_2 and U/LLP_{11}
U/L66	Line between two points at U/LRP_1 and U/LLP_{12}
U/L_1(CC/33)	Line between two point of U/L1 and U/LPj(Cs/3s)
U/L_1DD	Line between two point of U/L1 and U/LPj(Ds/4s)
U/L_1EE	Line between two point of U/L1 and U/LPjEs
U/$L_1$66	Line between two point of L/L1 and U/LPj6s

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