

# Maxillary and Mandibular Arch Forms in the Primary Dentition Stage

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## Abstract

**Objective:** To determine the most common maxillary and mandibular arch form and size in primary dentition stage.

**Material and methods:** Four hundred thirty five preschool children were included in this study with an age range of 3.5-5.5 years old. Dental casts were digitized and landmarks for the measurements were identified and marked on each model. Ten points were determined on the dental arch. Measurements of the x and y coordinates of the 10 points of each dental cast image were plotted on a computer software to obtain the polynomial function that best describes the curve corresponding to the dental arch form.

**Results:** Three arch forms were observed; square, oval and tapered. The most common arch form observed in the primary dentition was the oval form (52%) followed by the square and tapered arch forms (29% and 19%, respectively). Gender differences were not detected. In the maxilla, the most common arch form was the oval (58.4%) arch whereas the square arch form (46.7%) was the most common in the mandible. The medium size arch form was the most common size in both mandible (83%) and maxilla (71.5%) and for the total sample (77%). Differences in arch form size distribution were detected ( $P < 0.000$ ). Small size arch form was more common in females compared to males in the maxilla and total sample ( $P < 0.000$ ). Inter-canine width was significantly smaller in the tapered arch form compared to oval arch form ( $P = 0.048$ ).

In both arches, inter-canine and inter-molar widths were significantly larger in males compared to females.

**Conclusions:** The most common arch forms in the maxilla and mandible were the medium sized oval and square forms, respectively. Inter-canine width was the smallest in the tapered arch form.

Inter-canine and inter-molar widths were affected by gender.

*Key words: Arch form, Primary dentition, Children, Maxillary, Mandibular*

## Introduction

The dental arch form is defined as the curving shape formed by the configuration of the bony ridge. Basic characteristics of arch form include the radius of curvature of labial segment, inter-canine width and inter-molar width [1]. The dental arch size and shape undergo different changes throughout the growth of the supporting bones and the movement of teeth after their eruption, also the perioral muscles and the intraoral functional forces aid in the configuration of the dental arch [1-4].

Different methods have been developed to describe the dental arch morphology ranging from simple classification of arch shape, through combinations of linear dimensions, to complex mathematical equations [2].

Little focus had been directed toward studying the dental arch form in the primary dentition stage. De Castro et al. [5] carried out a cross sectional study in Brazil on the shape of the dental arches in the primary dentition on 188 subjects, children of 6 to 39 month old. They found out that 68.8% of the children had a rounded upper arch, while 31.4% had a triangular upper arch. As for the lower arch 92% of the children had a U shaped arch and 8% had a square shaped arch

This study was conducted to investigate the different arch forms in primary dentition stage. The hypothesis tested is that there is a single arch form for the maxilla and the mandible in primary dentition stage.

## Materials and Methods

Ethical approval for the study was obtained from the

Institutional Review Board at the Jordan University of Science and Technology. A total of 1771 preschool children (923 males and 848 females) of an age range of 3.5 – 5.5 years (mean age of  $4.52 \pm 0.56$  years) were examined at randomly selected schools from different districts in Jordan. Four hundred thirty five Jordanian (White ethnicity) students (232 males and 203 females) fulfilled the following inclusion criteria and were invited to participate in the study.

1. Class 1 incisor relationship
2. Bilateral mesial step or flush terminal plan molar relationships
3. Minimal crowding ( $< 3$  mm) or spacing
4. No or minor tooth rotations
5. No cross bite or scissor bite
6. All primary teeth erupted
7. No permanent teeth erupted
8. No missing or supernumerary teeth
9. No abnormally sized or shaped teeth
10. No history of orthodontic treatment- prefabricated orthodontic appliances
11. No damaged teeth due to caries (teeth with caries in the fissures only with intact walls were included).

Upper and lower alginate impressions and wax bite were taken. Impressions were poured within a few hours on the same day with hard dental stone.

## Measurements

Dental casts were digitized on scanner (HP scanjet G4010, Hewlett- Packard Company, Palo Alto, CA, USA) and images with 300 dpi resolution were obtained. The position of the dental casts on the scanner was established with a millimeter

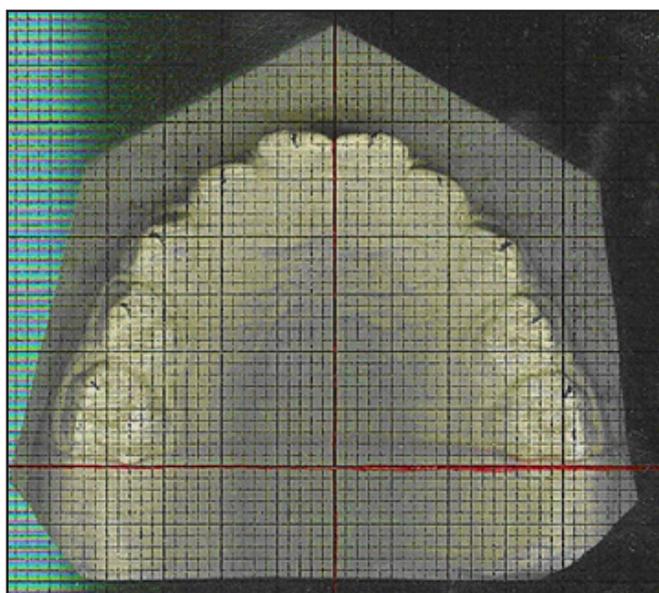
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translucent paper especially designed for this purpose. It was made by photocopying a sheet of millimeter paper on a transparent sheet and marking the x and y axes. The customized transparent sheet was placed between the scanner glass surface and the occlusal plane of the dental cast so that the posterior edge of the dental cast would coincide with the abscissa axis (x) and the dental midline with the ordinate axis (y), creating a Cartesian system (Figure 1).

For each cast image, landmarks for the measurements were identified and marked on each model by the same examiner. Ten points were determined on the dental arch representing the center of the clinical crown of the central and lateral incisors and canines, and the mesiobuccal cusps of the first and second molars. The perpendicular distance to the midline from each point was analyzed to an x and y components and measured in millimeters. Measurements of the x and y coordinates of the 10 points of each dental cast image were plotted on a computer software (Curve Expert version 1.4, Hyams Development, USA) to obtain the polynomial function that best describes the curve corresponding to the dental arch form. The following parameters were recorded:

**Arch form:** Different arch forms were produced according to the following procedure:

1. Each photo was converted to a (DAT format) file, using a Curve Expert program. The photo then appeared as a set of points (indices x and y) which was determined by the original photo.
2. An interpolation was done to these sets of points using MATLAB (version 7.4.0.287 (R2007a) the mathworks, Inc, Natick, Massachusetts, U.S.A) to form a polynomial function of sixth order  $Y=ax^6+bx^5+cx^4+dx^3+ex^2+fx+g$  where  $a \neq 0$  (Figure 2).
3. Each set of points contained 10 points, using the function generated by the interpolation process; a curve containing 100 points was generated.
4. In order to cover 100 steps on x- axis, a type of scaling was done on each set of points, then shifting all curves to start from the same point, which was zero.



**Figure 1.** A representation of the Cartesian system and the x and y measurements corresponding to the points used to establish the dental arch form.

5. The slope of each point relative to its neighbors was calculated.

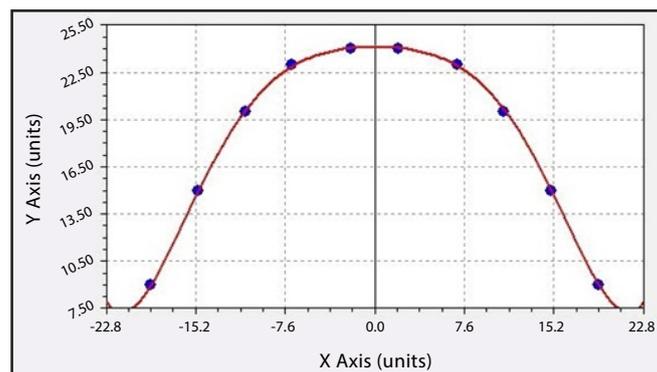
6. The slope of each point in each curve was compared to the slope of the points that shared the same x value, x+1 or x-1 in all other curves.

7. The curves were then allocated into different groups based on the slopes of the points on each curve.

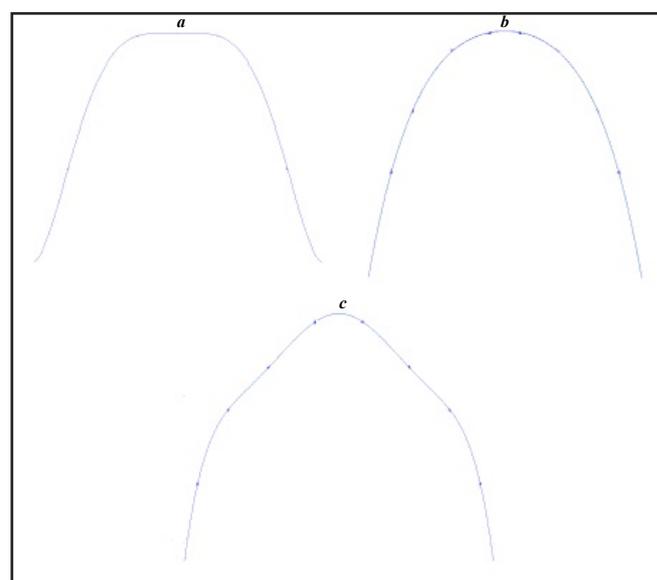
8. The biggest three groups (groups that contained most frequent types of curves) were made the main groups.

**Arch form size:** Each of the maxillary and mandibular curves was also divided into three sizes within each arch form according to the transverse distance between the tips of the mesiobuccal cusps of the right and left primary second molars [1]. The minimum distance was subtracted from the maximum distance; the difference was divided into three equal ranges (small, medium, large) (Table 2). The three ranges of distance between the second primary molars within each form in the maxilla and mandible are shown in Table 2. Each cast was allocated into one of these three groups according to its width between the second molar.

**Inter canine width:** Inter canine width was measured in millimeters as the distance from the cusp tip of the right canine to the cusp tip of the left canine.



**Figure 2:** The function screen window of the x and y coordinates and a plot of one arch as displayed in the Curve expert software.



**Figure 3.** a: Graphic representation of the square arch form in the mandible and maxilla. b: Graphic representation of the oval arch form in the mandible and maxilla. c: Graphic representation of the tapered arch form in the mandible and maxilla.

**Inter molar width:** Intermolar width was measured as the distance from the mesiobuccal cusp of the right second primary molar to the mesiobuccal cusp of the left second primary molar.

**Error of the method**

Twenty (10 upper and 10 lower) casts were randomly selected and re-analyzed and the arch parameters were re-measured after one month interval. Kappa statistics were used to evaluate the reliability of the categorical data [6]. Dahlberg’s formula [7] was used to calculate the standard error of method ( $S = \sqrt{\sum(X1 - X2)^2 / 2n}$ ) and Houston coefficient of reliability [8] was calculated. The results of the Kappa values were above 95% which indicate a substantial agreement between readings [9]. Dahlberg errors were 0.1 mm and 0.17 for intercanine and intermolar widths, respectively. The coefficients of reliability were above 90% for the measurements, indicating good agreement.

**Statistical analysis**

Data analysis was carried out using the Statistical Package for Social Science (SPSS) computer software (SPSS 16.0, SPSS Inc., Chicago, USA). Simple descriptive frequencies were recorded for the various arch forms. Chi square test

was employed to investigate if there are differences between the frequency of different arch forms and sizes in each of the maxilla and the mandible. Mann-Whitney test was also used to detect the relation between the gender and the arch forms. The mean difference between the intercanine and intermolar width was analyzed and recorded using One-way ANOVA and Bonferroni test.

**Results**

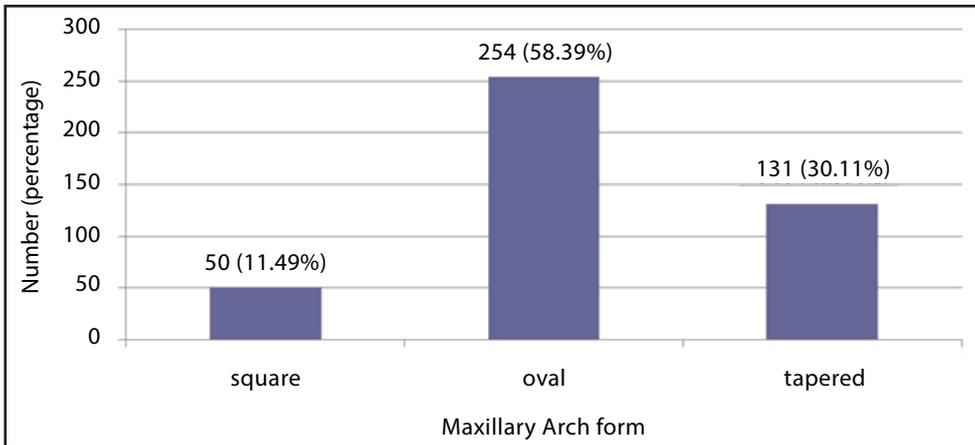
**Arch forms**

Three different forms were observed for maxillary and mandibular arches; squared, oval and tapered (Tudor) arch forms (Figure 3a-c). The frequency of each arch form as a percentage in females, males and the total sample is shown in Table 1 and Figures 4 and 5.

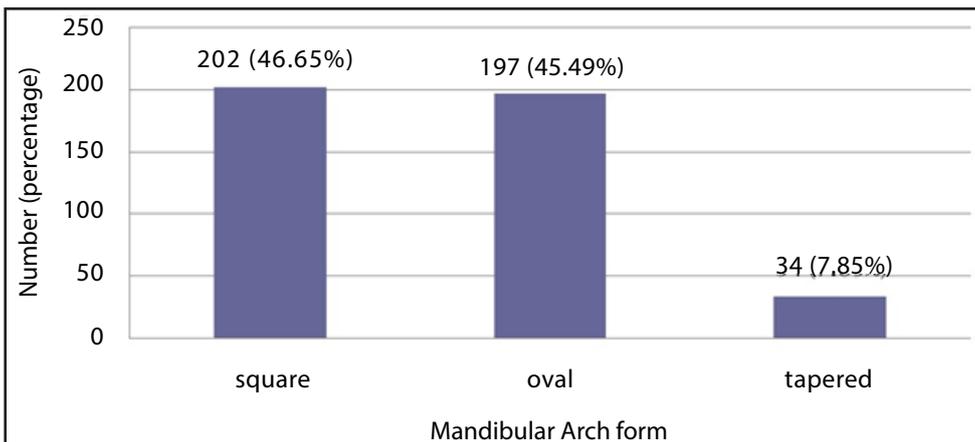
The most common arch form observed in the primary dentition was the oval form (52%) followed by the square and tapered arch forms (29% and 19%, respectively). The most common arch form observed in the mandible was the square form (46.7%) followed by the oval arch form in 45.5% of children. In the maxilla, the oval arch form was the most commonly observed (58.4%). The tapered (7.9%)

*Table 1. The frequency of each arch form in females, males and total sample and the p value for gender differences.*

	Maxilla			Mandible			Total		
	Square	Oval	Tapered	Square	Oval	Tapered	Square	Oval	Tapered
<b>Males N (%)</b>	21 (42.0)	140 (55.1)	71(54.2)	98 (48.5)	110 (55.8)	23 (67.6)	119 (25.7)	250 (54.0)	94 (20.3)
<b>Females N (%)</b>	29 (58.0)	114 (44.9)	60 (45.8)	104 (51.5)	87 (44.2)	11 (32.4)	133 (32.8)	201 (49.6)	71 (17.5)
<b>Total N (%)</b>	50 (11.5)	254 (58.4)	131 (30.1)	202 (46.7)	197 (45.5)	34 (7.9)	252 (29.0)	451 (52.0)	165 (19.0)
	(2.945, P=0.229)			(5.180, P=0.075)			(5.456, P=0.065)		



*Figure 4. Distribution of subjects in each arch form in the maxilla.*



*Figure 5. Distribution of subjects in each arch form in the mandible.*

and the square (11.5%) arch forms were the least observed in mandible and the maxilla, respectively. Gender differences were not observed ( $X^2=2.945, P=0.229, X^2=5.180, P=0.075; X^2=5.456, P=0.065$  for maxilla, mandible and total sample, respectively).

**Arch size**

When the recorded minimum intermolar distance was subtracted from the maximum one, the difference was divided into three ranges. The arches were divided into 3 sizes: small, medium, and large within each arch form (Table 2). Each

cast was allocated into one of these three groups according to its width between the second molar. The distribution and percentages of subjects in each arch form according to size in the maxilla and the mandible are shown in Table 3 and Figures 6 and 7.

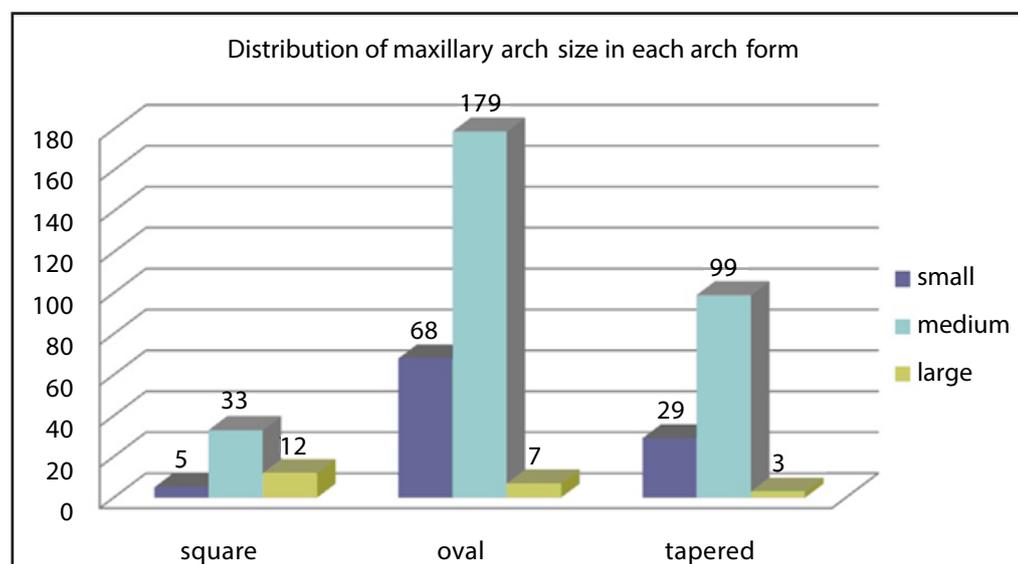
The medium size arch form was the most common size in mandible (83%), maxilla (71.5%) and total sample (77%). Difference in arch form size distribution was detected ( $P=0.000$ ). Also, it was the most common size in all forms in the maxilla (square, oval and tapered). In the lower jaw, the

*Table 2. The ranges of distances measured in millimeters that determined arch size of each curve.*

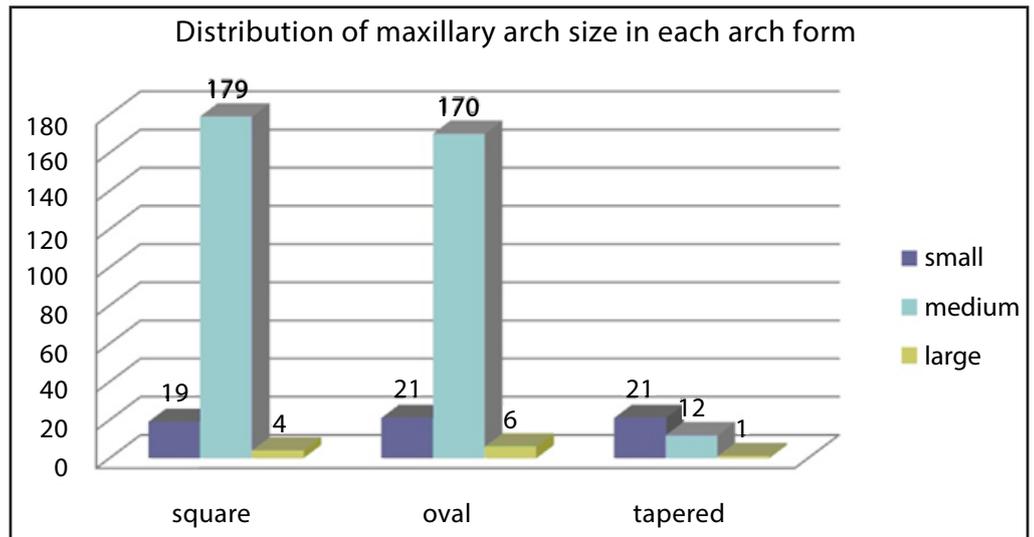
Sizes	Maxilla			Mandible		
	Small	Medium	Large	Small	Medium	Large
Square	32-37	38-43	44-48	30-36	37-43	44-48
Oval	32-37	38-43	44-48	22-33	34-45	46-56
Tapered	30-39	40-49	50-58	28-36	37-45	46-54

*Table 3. The distribution and percentages of subjects in each arch form according to size.*

Arch form	Maxilla			Mandible			Total		
	Small N (%)	Medium N (%)	Large N (%)	Small N (%)	Medium N (%)	Large N (%)	Small N (%)	Medium N (%)	Large N (%)
<b>Total sample</b>									
Square	5 (10.0)	33 (66.0)	12 (24.0)	19 ( 9.4)	179 (88.6)	4 (2.0)	24 (9.5)	212 (84.1)	16 (6.3)
Oval	68 (26.8)	179 (70.5)	7 (2.8)	21 (10.7)	170 (86.3)	6 (3.0)	89 (19.7)	349 (77.4)	13 (2.9)
Tapered	29 (22.1)	99 (75.6)	3 (2.3)	21(61.8)	12 (35.3)	1 (2.9)	50 (30.3)	111 (67.3)	4 (2.4)
Total	102 (23.4)	311 (71.5)	22 (5.1)	61 (14.1)	361 (83.4)	11 (2.5)	163 (18.8)	672 (77.4)	33 (3.8)
	$(X^2=45.820, P=0.000)$			$(X^2=70.409, P=0.000)$			$(X^2= 33.169, P=000)$		
<b>Females</b>									
Square	4 (13.8)	19 (65.5)	6 (20.7)	15 (14.4)	87 (83.7)	2 (1.9)	19 (14.3)	106 (79.7)	8 (6.0)
Oval	43 (37.7)	70 (61.4)	1 ( 0.9)	13 (14.9)	71 (81.6)	3 (3.4)	56 (27.9)	141 (70.1)	4 (2.0)
Tapered	17 (28.3)	43 (71.7)	0 (0.0)	8 (72.7)	3 (27.3)	0 (0.0)	25 (35.2)	46 (64.8)	0 (0.0)
Total	64 (31.5)	132 (65.0)	7 (3.4)	36 (17.8)	161 (79.7)	5 (2.5)	100 (24.7)	293 (72.3)	12 (3.0)
	$(X^2=34.366, P=0.000)$			$(X^2=24.456, P=0.000)$			$(X^2=18.448, P=0.001)$		
<b>Males</b>									
Square	1 (4.8)	14 (66.7)	6 (28.6)	4 (4.1)	92 (93.9)	2 (2.0)	5 (4.2)	106 (89.1)	8 (6.7)
Oval	25 (7.9)	109 (77.9)	6 (4.3)	8 (7.3)	99 (90.0)	3 (2.7)	33 (13.2)	208 (83.2)	9 (3.6)
Tapered	12 (16.9)	56 (78.9)	3 (4.2)	13 (56.5)	9 (39.1)	1 (4.3)	25 (26.6)	65 (69.1)	4 (4.3)
Total	38 (16.4)	179 (77.2)	15 (6.5)	25 (10.8)	200 (86.6)	6 (2.6)	63 (13.6)	379 (81.9)	21 (4.5)
	$(X^2=19.716, P=0.001)$			$(X^2=56.906, P=0.000)$			$(X^2=23.842, P=0.000)$		



*Figure 6. Distribution of subjects according to the size of arch form in the maxilla.*



**Figure 7.** Distribution of subjects according to the size of arch form in the mandible.

medium size was the most common in both square and oval shapes. The tapered archform, however, had the small size as the most common. Gender differences were detected in arch size distribution. Small size arch form was more common in females compared to males in maxilla and total sample ( $X^2=14.772$  and  $X^2=18.064$ , respectively). The differences were significant at  $P<0.000$ ). No gender differences were detected in arch size in the mandible ( $X^2=4.365$ ,  $P=0.113$ ).

#### Arch parameters

The means and Standard Deviations (SD) of the intercanine width and the intermolar width for each arch form in males and females for both the maxilla and the mandible are shown in *Table 4*.

Intercanine width was significantly smaller in the tapered arch form compared to oval arch form ( $P=0.048$ ).

The measurements for the males exceeded those of females (*Table 4*). In both arches, intermolar width was significantly larger in males. Intermolar width in upper arch was on average 43.03 (4.48) mm in males and 40.96 (3.34) mm in females. A difference of 2.07 mm was statistically significant ( $P<0.001$ ). In the lower arch, intermolar width was 37.26 (3.68) mm in males and 35.81 (3.64) mm in females. The difference was significant at the  $P<0.001$  level.

Intercanine width in upper arch was on average 29.93 (3.35) mm in males and 28.53 (2.66) mm in females. A difference of 1.40 mm was statistically significant ( $P<0.001$ ). In the lower arch, intercanine width was 23.75 (2.68) mm in males and 23.12 (2.62) mm in females. The difference was significant at the  $P<0.05$  level.

## Discussion

The identification of the different forms of dental arches in the primary dentition stage had been taking a lot of interests after the introduction of the different prefabricated habit breakers and trainers. It appears that basic information on children arch forms is still scanty in the literature. Thus, the present level of knowledge on this matter could be improved in order to provide help for paediatric dentists in their current practice.

In this study, the most common arch form was the oval arch. The oval and square arch forms were the most commonly observed arch forms in the mandible and maxilla, respectively. The result of this study was in agreement with

De Castro et al. [5] who suggested that 70% of subjects in their study had oval and square maxillary arch forms (58.39% and 11.49%, respectively). Nevertheless, the mandibular forms had different outcomes. De Castro et al. [5] found out that only 8% of their sample has a square shaped form, while almost the same percentage in the present study was reported to be tapered shaped. The tapered arch form was not reported to be present in the lower jaw of the Brazilian children. The oval shaped mandibular arch was reported in 45.5% of the Jordanian children while double that percentage (92%) was estimated by De Castro et al. [5] for the Brazilians. Such differences could be attributed to differences among different ethnic groups, classification used in both studies, different age groups and sample size.

Also, the result of this study is in partial agreement with Pinkham et al. [10] who suggested that the maxillary arch can be either U or V shaped while the mandibular arch is usually U. The square shaped was not reported by the same author, who classified the arch forms to either U- or V- shaped. This may be explained by the assumption that the square shaped may have been classified with the oval form. However, Pinkham et al. [10] did not report any percentages.

In this study, gender differences were detected. This was in disagreement with the above two studies [5,10].

In this study, medium size arch forms were the most common. This was in agreement with Triviño and Vilella [11] who stated that medium-sized dental arches are generally predominant in normal occlusion. In a more recent study, Triviño et al. [1] suggested that 6 out of 8 dental arch forms had more curve segments in a medium size.

In this study, the intercanine width was taken between the tips of the right and left canine, while the intermolar width was taken from the right mesiobuccal cusp of the second primary molar to the left. In comparison with this study, Abu Alhaija and Qudeimat [12] had greater intermolar widths, unlike the intercanine width which tended to be of similar widths. The difference in the intermolar width compared to Abu Alhaija and Qudeimat [12] may be due to the different measurement landmarks that were used to measure the arch dimensions.

In Poland, a study was conducted on 50 preschool children of 5 year old [13]. Unlike our study, the intermolar width was taken from the central fossa of the right and left second

**Table 4.** Mean and Standard Deviation (SD) of intercanine and intermolar widths of the different arch forms in males and females for both maxilla and mandible.

	Maxilla						Mandible					
	Intercanine width			Intermolar width			Intermolar width			Intermolar width		
	Males Mean (SD)	Females Mean (SD)	Mean Diff	Males Mean (SD)	Females Mean (SD)	Mean Diff	Males Mean (SD)	Females Mean (SD)	Mean Diff	Males Mean (SD)	Females Mean (SD)	Mean Diff
<b>Square</b>	30.10 (2.86)	28.69 (3.04)	1.41	41.81 (2.68)	40.83 (3.27)	0.98	24.16 (2.31)	23.33 (2.24)	0.84**	37.33 (3.61)	35.79 (3.15)	1.54***
<b>Oval</b>	30.16 (3.62)	28.39 (2.65)	1.77***	43.61 (4.65)	41.19 (3.18)	2.42***	23.42 (2.81)	23.01 (2.89)	0.41	37.15 (3.49)	35.91 (4.24)	1.24*
<b>Tapered</b>	29.44 (2.87)	28.73 (2.52)	0.70	42.23 (4.42)	40.57 (3.67)	1.66*	23.57 (3.30)	22.00 (3.58)	1.57	37.57 (5.59)	35.27 (3.13)	2.29
<b>Total</b>	29.93 (3.35)	28.53 (2.66)	1.40***	43.03 (4.48)	40.96 (3.34)	2.07***	23.75 (2.68)	23.12 (2.62)	0.63*	37.26 (3.68)	35.81 (3.64)	1.45***

\* $P < 0.05$ , \*\* $P < 0.01$ , \*\*\* $P < 0.001$

primary molar. Despite the ethnic diversity between this study and this polish study [13], the intercanine width was within the same range as our measurements, while the intermolar width was lesser than our results, and this was due to the different landmarks used in measuring the intermolar width.

Gender differences in intercanine and intermolar arch widths were detected in this study. This was in agreement with Knott [13] who reported larger dental arch widths in males than females. The statistical significance of the gender differences in intercanine and intermolar widths contradict earlier findings by Abu Alhaija and Qudeimat [12] for intercanine, but not intermolar width. The difference may be explained by the difference in sample size in both studies.

The findings of this study will form base line data for the shape and size of arch forms for the selection of stock trays, prefabricated orthodontic appliances and habit breakers for children in the primary dentition stage.

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## Conclusions

- The most common form in the maxilla was the oval shaped.
- The most common arch form in the mandible was the square shaped.
- The medium size arch form was the most common arch form size.
- Intercanine and intermolar widths were affected by gender.
- Intercanine width was the smallest in the tapered arch form.

## Acknowledgement

The study was supported by grant number 138/2010 from the Deanship of Research/Jordan University of Science and Technology.

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