LONGITUDINAL STUDY OF DENTAL ARCH WIDTH, LENGTH AND PALATAL MEASUREMENT CHANGES OCCURRING IN THE TRANSITIONAL PERIOD FROM MIXED TO PERMANENT DENTITION IN SULAIMANI

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ABSTRACT

Background

Knowledge of arch dimensions is useful in providing a smooth occurrence of transient malocclusion, in predicting future orthodontic problems, normal occlusal changes in mixed dentition, and proper sequential exchange of permanent teeth. Moreover, dental arch dimensions change systematically during the period of intensive growth, development and less so in adulthood. The findings of the present study exhibited the highly significant greater mean value for males than females in both mixed and permanent dentitions except dental arch length and total arch length measurements in the permanent dentition in which no significant differences were reported.

Objective

This longitudinal study was conducted to investigate dental arch width, length and depth changes that happen at two different stages of dentition in 40 (20 males and 20 females) normal occlusion Kurdish children.

Materials and methods

Dental casts were obtained and measurements were analyzed twice with 5 years intervals using digital sliding calipers with 0.001 sensitivity. First measurement was in mixed and second one in permanent dentition. The data were analyzed using SPSS (version 15) program.

Results

The results showed that width changes in maxilla and mandible were significantly more in the permanent dentition than mixed dentition. Additionally, the findings demonstrated a greater mean value of measurements for males than females in both mixed and permanent dentitions except dental arch length (DAL) and total arch length (TAL) in the permanent dentition. Thus, significant sexual dimorphism was observed in most dimensions measured.

Conclusion

The outcome of the present study demonstrates that changes in dental arch dimensions should be taken in consideration during orthodontic treatments rendering the upshot of the treatment more acceptable.

Keywords: *Longitudinal study, dental arch dimensions, mixed and permanent dentitions*.

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INTRODUCTION

The analyses of dental size and arch dimensions establish human biological characteristics, such as the genetic relationship between populations and the adaptation of humans to their place of residence. Odontometrics is one of the least studied areas of Dentistry, so the variations and factors that affect normal growth are not understood [(1)]. Knowledge of arch dimensions is useful in predicting future orthodontic problems, normal occlusal changes in mixed dentition, and proper sequential exchange of permanent teeth [(2)]. Additionally, dental arch dimensions change systematically during the period of intensive growth and development and less so in adulthood [(3)], because of tooth movement and the growth of the supporting bone [(4)].

The clinical implications of arch dimensions are of utmost importance in orthodontic therapy [(5)]. Intermolar and intercanine widths increased in the older population, but were more extreme in females, probably because girls finish tooth eruption before boys, except for third molars [(6)].

Longitudinal studies on arch growth have shown an increase in arch width up to the age of 13 years, with very little significant growth after that period [(7)]. Some studies even noted a slight decrease in arch size [(7)]. In the dental arch, relatively rapid changes occur during transitional dentition, and once a functional permanent dentition is established, smaller changes are observed to continue [(3)]. Understanding of the sagittal and transversal changes that occur between mixed and permanent dentitions in the maxillary and mandibular arches is crucial for the clinician interested in early orthodontic treatment [(8)]. It was established that there is a characteristic form of the arches for each ethnic group. Since different intercanine and intermolar widths were found between different ethnic groups. Thus, characteristics in each population should be considered because of their influence on the craniofacial morphology [(4)].

A longitudinal study of arch dimensions in Kurdish population is essential for accurate assessment of changes which occur in response to an increase in age. Thus, the purpose of this study was to investigate dental arch width, length and depth changes that occur in transition from mixed dentition to permanent dentition in Kurdish children and to observe the sex differences.

MATERIALS AND METHODS

After obtaining the approval of Ethical Committee of Faculty of Medical Science/School of Dentistry / University of Sulaimani as well as the consent of the participated children, in addition to their parents as the children were underage, a total of 40 children, 20 males and 20 females, were randomly selected with normal occlusion. Two alginate impressions of each of the maxillary and mandibular dental arches were taken (the first was done at 8-9 years and the second at 13-14 years) for all children, and then dental stone poured into the impressions immediately. Upper and lower dental casts obtained and were used for measuring various dental arch dimensions. Two analyses were done. The first was done at the age of the end of early mixed dentition or rather the silent or lull stage (8–9 years) and the second analysis at the permanent dentition stage (13-14 years) using digital sliding calipers with 0.001 sensitivity.

Criteria of sample selection:

The eruption of the first molar and/or permanent incisors was the criteria of sample selection at the beginning of study. Moreover, all selected subjects were healthy free from any abnormal chronic condition affecting growth throughout the study. Absence of crowding and no history of orthodontic treatment were also taken in consideration.

Parameters:

1. Dental arch width:

a- Inter-canine width (C-C): The linear distance from the cusp tip of one canine to the cusp tip of the other.

b- Inter-molar width (M-M): The distance from the mesio-buccal cusp tip of one first permanent molar, to the mesio-buccal tip of the other.

2. Dental arch lengths:

a- Anterior arch length (I-CC): The perpendicular distance from a point between the central incisors to a line connecting the cusp tips

b- Molar – vertical distance (I-MM): The perpendicular distance from a point between the central incisors to a line connecting the mesio-buccal cusp tips of the first permanent molars.

3. Palatal measurements:

a- Palatal depth: The vertical distance from a point at line joining the mesio-lingual cusp tips of the first permanent molar to the corresponding palatal vault in the midline. It was measured manually by the Korkhaus three-dimensional orthodontic divider.

b- Palatal width: the linear distance between the mesio-lingual cusp tips of the right and left first permanent molars.

c- Palatal length: this distance is equivalent to molar – vertical distance at the mesio-lingual cusp tip of the first permanent molar.

4. Total arch length (TAL): the sum of the distances between the most mesial point on the canine and the most distal point on the first molar on both sides.

5. Dental arch length (DAL): the distance between inter molar distance line and the labial surface of the most prominent central incisor.

Statistical Analysis:

The data was analyzed by using statistical package for social sciences (SPSS, version 15) software for obtaining both descriptive statistics (including the mean, standard deviation) and inferential statistics (t-test to find the significance difference between the dimensions).

The critical level of statistical significance was determined at a probability level of less than or equal to 0.05. Paired t-test was used to determine the changes that occur during growth. Student's t-test was used to assess the sex differences regarding the measurements.

RESULTS

Total arch length and dental arch length were more in mixed dentition than permanent dentition in both maxilla and mandible. Almost all width changes in maxilla and mandible were significantly more in the permanent dentition than mixed dentition including inter- canine, inter-molar and palatal width, tables 1 and 2.

In regard to arch length changes in maxilla: anterior arch length was significantly greater in permanent dentition whereas dental arch length and total arch length were more in mean value in mixed dentition. Additionally, the decrease of the latter in transition to permanent dentition was highly significant. In reference to depth changes in maxillary arch, palatal depth increased 3.94 mm in permanent dentition, tables 1 and 2.

The outcomes of arch length changes in mandible showed highly significant decrease in total arch length and dental arch length in permanent dentition, the decrease was about 3.04 mm and 1.22 mm, respectively. The findings of the present study exhibited the highly significant greater mean value for males than females in both mixed and permanent dentitions except DAL and TAL measurements in the permanent dentition in which no significant differences were reported, tables 3 and 4.

Table 1. Maxillary dental arch changes.

		Mixed dentition			Permanent dentition				
	Parameters	No.	Mean	±SD	N0.	Mean	±SD	t- test	P value
Width changes	**C-C**	40	32.99	0.827	40	35.6	1.08	16.017	0.000*
	M-M	40	50.15	1.57	40	51.07	1.22	9.77	0.000*
	Palatal width	40	39.24	1.48	40	40.01	1.65	5.509	0.000*
Length changes	**I-CC**	40	8.35	0.906	40	9.77	0.85	13.07	0.00*
	I-MM (DAL)	40	29.74	0.84	40	29.57	0.55	1.115	2.72
	TAL	40	45.73	2.27	40	43.75	2.12	8.020	0.000*
Depth changes	**Palatal depth**	40	14.04	1.09	40	17.98	1.88	26.009	0.000*

C-C: inter canine width, M-M: inter molar width, I-CC: anterior arch length, I-MM (DAL): molar- vertical distance, TAL: total arch length.

* Highly significant difference

Table 2. Mandibular dental arch changes.

	Parameters	Mixed dentition No.	Mean	±SD	Permanent dentition No.	Mean	±SD	t-test	P value
Width changes	C-C	40	26.22	1.24	40	28.38	2.66	5.84	0.00*
	M-M	40	43.86	1.16	40	44.85	1.29	6.82	0.00*
Length changes	I-CC	40	5.9	1.26	40	6.57	0.87	8.57	0.000*
	I-MM (DAL)	40	26.55	0.911	40	25.33	0.81	20.19	0.000*
	TAL	40	47.40	0.85	40	44.36	0.96	14.99	0.000*

C-C: inter canine width, M-M: inter molar width, I-CC: anterior arch length, I-MM (DAL): molar- vertical distance, TAL: total arch length.
* Highly significant difference

Table 3. Distribution of the study sample according to sex in the maxillary arch.

	Parameters	Sex	No.	Mean	±SD	t-test	P- value
Mixed dentition	C-M (DAL)	Male	20	23.14	1.14	1.525	0.135
		Female	20	22.60	1.09		
	TAL	Male	20	46.29	2.28	1.563	0.126
		Female	20	45.19	2.18		
	C-C	Male	20	33.41	0.69	3.727	0.001*
		Female	20	32.57	0.73		
	M-M	Male	20	50.84	1.433	3.046	0.004*
		Female	20	49.46	1.421		
	I-CC	Male	20	8.475	0.920	0.825	0.414
		Female	20	8.237	0.899		
	I-MM	Male	20	30.11	0.89	3.060	0.004*
		Female	20	29.37	0.608		
	Palatal width	Male	20	39.84	1.05	2.774	0.009*
		Female	20	38.64	1.624		
	Palatal depth	Male	20	14.37	1.20	1.934	0.08
		Female	20	13.72	0.88		
Permanent dentition	C-M (DAL)	Male	20	21.99	1.05	0.698	0.489
		Female	20	21.75	1.09		
	TAL	Male	20	43.98	2.10	0.666	0.51
		Female	20	43.53	2.17		
	C-C	Male	20	36.22	1.16	4.319	0.000*
		Female	20	34.99	0.517		
	M-M	Male	20	51.56	0.75	2.767	0.009*
		Female	20	50.57	1.40		
	I-CC	Male	20	10.26	0.30	4.373	0.000*
		Female	20	9.28	0.946		
	I-MM	Male	20	29.61	0.662	0.480	0.634
		Female	20	29.52	0.433		
	Palatal width	Male	20	41.09	0.701	5.409	0.000*
		Female	20	38.93	1.64		
	Palatal depth	Male	20	18.81	2.014	3.069	0.004*
		Female	20	17.16	1.325		

C-M: canine molar distance, C-C: inter canine width, M-M: inter molar width, I-CC: anterior arch length, I-MM (DAL): molar- vertical distance, TAL: total arch length.
* Highly significant difference

Table 4: Distribution of the study sample according to sex in the mandibular arch.

	Parameters	Sex	No.	Mean	±SD	t-test	P- value
Mixed dentition	**C-M (DAL)**	Male	20	23.92	0.22	9.921	0.000*
		Female	20	23.23	0.207		
	TAL	Male	20	47.85	0.45	3.845	0.000*
		Female	20	46.95	0.93		
	C-C	Male	20	26.49	1.187	1.40	0.170
		Female	20	25.95	1.27		
	M-M	Male	20	44.86	0.687	10.93	0.000*
		Female	20	42.86	0.442		
	I-CC	Male	20	6.13	1.233	1.161	0.252
		Female	20	5.66	1.29		
	I-MM	Male	20	26.98	0.80	3.327	0.002
		Female	20	26.12	0.82		
Permanent dentition	**C-M (DAL)**	Male	20	22.06	0.38	1.445	0.156
		Female	20	22.28	0.57		
	TAL	Male	20	44.16	0.71	1.335	0.190
		Female	20	44.57	1.15		
	C-C	Male	20	29.91	2.787	4.410	0.000*
		Female	20	26.85	1.37		
	M-M	Male	20	45.99	0.80	12.111	0.000*
		Female	20	43.71	0.25		
	I-CC	Male	20	6.60	0.73	0.188	0.825
		Female	20	6.55	1.007		
	I-MM	Male	20	25.56	0.704	1.882	0.06
		Female	20	25.09	0.859		

C-M: canine molar distance, C-C: inter canine width, M-M: inter molar width, I-CC: anterior arch length, I-MM (DAL): molar- vertical distance, TAL: total arch length

* Highly significant difference

DISCUSSION

Evaluation of dental arch changes is of great importance for definitive diagnosis and optimal craniofacial treatment. The values of the dimensions of the arch include: width, depth and circumference, intercanine and intermolar distances, overjet and overbite, which change during growth in different ways (the width of the teeth remains the same, whereas the lengths of the mandibular and maxillary bones increase [(2)].

Mixed dentition is the stage in which most of width changes occurred relating to the growth of the jaws. Thereafter, these changes would be minimal. Accordingly, arch width dimensions should be estimated in the mixed dentition [(10)].

In this study a selected fixed reproducible control points were depended, using tooth related points instead of alveolar points. Besides, measurements taken from a definite cusp tip to a corresponding definite cusp tip are very reliable [(11)].

The result of this study showed a larger dimensions for males in comparison with females which is similar to many studies [Cassidy, *et al*. [(7)], Staley, *et al*. [(12)], Raberin, *et al*.[14]], as maxillary or /and mandibular widths were larger in males than in females subjects. However, Slaj *et al*. [(14)] reported that no width or depth variables indicated a statistically significant sexual dimorphism.

Since the entire mean values of males are larger than that of females, the results confirming the opinion that males dental arches are larger than of females in the first session of measurements. The same opinion was true for the second measurement except that of total arch length which may be attributed to more mesial migration of permanent first molar in males due to slower growth rate in males during the period of shedding of primary molars and eruption of permanent molars.

At the same time, our results differed from those reported by Nojima [(15)] and Ferrario *et al*. [(17)], who concluded that there is no sexual dimorphism in the dental arches and this is not necessary to establish gender groups because there are similar male-to-female ratios in ethnic populations.

In many studies, maxillary and/or mandibular widths were larger in male than in female subjects

[8]. However, in the present investigation, no width or depth variables indicated a statistically significant sexual dimorphism. This corresponds with the findings of Ferrario *et al*. [16] who suggested that arch size was not influenced by sex in their sample.

Total arch length and dental arch length were significantly more in mixed dentition than permanent dentition in both maxilla and mandible. These decreases were more in mandible than maxilla due to more mesial migration of mandibular first molars and this because of greater mandibular Leeway space [8].

Because a number of orthodontic treatments may be planned or applied in the period of early or late mixed dentition, the definition of the exact stage of the mixed dentition is of utmost importance for deciding upon and administering the appropriate orthodontic therapy.

Inter-molar distance: significant difference was found in I-M width between first and second measurements with a larger mean value for the second one. The results come in agreement with other studies [5,8]. In the present study, both maxillary and mandibular inter canine width showed a significant increase 2.7 mm, and 2.16 mm, respectively. Although, Knott reported similar findings, Sincliar and Little [17] reported that inter canine width showed non-significant difference in mandible. The cause of inter canine width increase in maxilla was growth in the median suture during normal growth [18].

Rivera *et al*. [19] suggested that the dimensions of arch width are genetically determined in a more specific way than the dimensions of arch length. The inter-canine and inter-molar widths do not change after age of 13 years old in females and 16 years old in males [20]. The inter-canine distance increases significantly in the changeover dentition.

The findings of this study, as well as those of Bishara *et al*. [21] and Louly *et al*. [18] indicate that most arch widths dimensions are established in the early mixed dentition. The minimal width changes that occur during the late mixed dentition are not a factor that should influence a treatment plan. On the contrary, changes in the growth direction— different in the maxilla and mandible—do have significant clinical application.

One of the most interesting findings in the present study was the development of palatal height. In earlier studies, the length and width of the dental arches have been the focus of attention, while information of the development of palatal height in normal subjects is lacking. Björk and Skieller [22] reported that palatal depth increased with age in both sexes. An increase in palate depth was 3.94 mm in the present study whereas an increase was 3.19 mm in the study conducted by Yuvus and Oktay in 2006 on Turkish children [8] and continuous increase in palatal height 0.1 mm / year observed in a study by Thilander [23] and this seems to be an effect of a slow continuous eruption of the teeth. Even if the mechanisms of tooth eruption have still not been fully elucidated, the slow continuous increase of this distance seems to indicate an important role in the eruption mechanisms. This knowledge is of importance in explaining the infraposition of an implant-supported crown as a continuous eruption of its adjacent teeth in addition; dimensional increase in the arches also associated with eruption of the teeth [23].

The occlusion should be regarded as a dynamic rather than a stable interrelationship between facial structures. This natural development has to be considered in orthodontic treatment planning as well as in assessment of stability following orthodontic treatment. However, trend nowadays is toward the prevention of malocclusion rather than complicated orthodontic treatment so; such valuable information about normal development of arch will help to diagnosis more appropriately in early stages of routine dental checkup and examination. Since Contemporary children have a greater probability for developing a malocclusion compared with the children living 35 years before according to Defraia *et al*. study 2006 [24].

Finally, the dynamics of facial development with variations in maxillary and mandibular growth, together with concomitant dento-alveolar development, need to be better understood before orthodontists can expect to achieve more stable treatment results.

In conclusion, the outcome of the present study demonstrates that changes in dental arch dimensions should be taken in consideration before and during orthodontic treatments rendering the upshot of the treatment more acceptable.

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