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ORIGINAL RESEARCH

Assessment of dental arch forms in a sample of children

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Abstract

In this study, we investigated dental arch forms in a representative sample of children with mixed dentition. Twenty-four pairs of study models, belonging to twenty-four youngsters (twelve boys and twelve girls aged 8 to 9 years) with acceptable occlusion, were scanned and assessed by Ortho analyzer software. Three transversal and three vertical measurements were acquired to evaluate the lengths and widths of dental arches, and the ratios between these measurements were standardized. Next, the mean standardized parameters were used to define the dental arch form. Unpaired *t*-tests were used to analyze gender differences for all measures. Subsequently, frequencies and percentages were determined for each arch shape in both jaws and genders, and Pearson's Chi-squared test was used to evaluate differences between genders. Males exhibited higher mean values for all measurements, but without statistical significance. The most prevalent dental arch was the mid form (83.3%) for both jaws and genders.

Keywords

Dental arch form; Mixed dentition; Pedodontics; Children; Pediatric

1. Introduction

Orthodontists and dentists who are interested in early orthodontic treatment or intervention should comprehensively understand the differences between mixed and permanent dentitions in both dental arches in three space planes [1]. The proportions of the dental arch do not remain constant during periods of intense growth and development [2, 3]. Rather, the size and shape of dental arches can be influenced by a variety of factors, including sutural growth in the maxilla, alveolar bone remodeling [4, 5], the inter-arch relationship of the teeth, and the contractile characteristics of supracrestal fibers [6]. During the transitional period between the primary and permanent dentitions, the dental arch undergoes rapid modifications; however, once a functioning permanent dentition is established, there is a significant reduction in alterations [7]. These modifications are attributable to tooth movement, bone expansion and modest hereditary components [8].

Researchers have previously investigated variations in dental arch proportions at each stage of development [9] and concluded that each ethnic group has a distinctive dental arch morphology. Due to the fact that intercanine and intermolar widths vary across ethnic groups, it is vital that we evaluate these parameters for each community because they can influence craniofacial morphology [10]. Several studies have attempted to quantify the dental arch dimensions and traits unique to a given ethnic group among children during the mixed dentition stage [11–14]. The dental arch form refers to the arch produced by the facial and buccal surfaces of the teeth when seen from their occlusal surfaces [15]. The shape of the dental arch is commonly believed to be initially determined by the underlying bone structure; when the teeth erupt, the shape of the dental arch then becomes affected by the oral musculature [16]. According to Tiwari *et al*. [15] and Barrow and White [17], there are five primary dental arch forms: parabolic, hyperbolic, ellipsoidal, square and omega. These arch forms can be determined by applying different methods such as catenary curves, pentamorphic arch forms of Ricketts, or mathematical equations. However, there is a significant lack of studies attempting to identify dental arch forms during the mixed dentition stage; in contrast, numerous studies have determined dental arch forms during the permanent dentition stage [18, 19]. Therefore, in the present study, we aimed to determine the dental arch dimensions and forms in a sample of children during the mixed dentition stage.

2. Materials and methods

2.1 Samples

This retrospective study involved twenty-four pairs of study models that were retrieved from the archive of the Pedodontics, Orthodontics and Preventive Dentistry department at the College of Dentistry, Mustansiriyah University. These models belonged to 24 children (twelve boys and twelve girls aged between 8 and 9 years) who were selected from several primary schools in Baghdad City. The inclusion criteria for sample selection included healthy children in the mixed dentition stage with no history of bad oral habits or craniofacial anomalies, children belonging to varying socioeconomic statuses with good dentition devoid of cavities, proximal restorations, or the loss of dental material for any reason, with no size, shape or structural anomalies, and normal skeletal and dental relationships in the three planes of space. In addition, the models needed to be devoid of voids, cracks, fractures, abnormalities, or technical flaws.

2.2 Methods

The stone models were scanned using 3 shape Company's D700 3D lab scanner (Copenhagen, Denmark) and dental arch widths and lengths were measured using Ortho analyzer software (version: 1.9.2.4, 2019 from 3 shape, Copenhagen, Denmark). Dental arch widths were measured at the level of the tips of the primary canines, the mesiobuccal cusps of the primary second molars, and the distobuccal cusps of the permanent first molars for both dental arches. Dental arch lengths were measured from the incisal point perpendicular to a line connecting the inter-canine distance (anterior arch length), the inter-primary second molar distance, and the inter-permanent first molar distance (total arch length) as shown in Figs. 1,2 .

Dental arch forms were calculated by computing the standard mean ratios of six dental cast measurements, including anterior arch length/inter-canine distance, primary second molar vertical distance/inter-primary second molar distance, and total arch length/inter-permanent first molar distance. The dental arch forms were therefore categorized as follows [18, 19]: narrow arch form (when the mean of the standardized number was $>+1$); mid arch form (when the mean of the standardized number was between +1 and -1), and wide arch form (when the mean of the standardized number was <-1).

2.3 Statistical analysis

Data were analyzed by SPSS software version 25 (IBM SPSS statistics, New York, NY, USA) to determine the intra-class correlation coefficient, means, and standard deviations of the linear measurements. We used independent samples t-tests to compare differences between genders. The shapes of the dental arches were determined as frequencies and percentages for both genders and arches, and Pearson's Chi-squared test was performed to identify differences between genders for both arches.

3. Results

First, we determined intra-class correlation coefficients to evaluate inter- and intra-examiner reliability. Analysis revealed outstanding reliability (0.96 for intra-examiner reliability and 0.94 for inter-examiner reliability). Table 1 presents the means, standard deviations, and gender differences for vertical and horizontal dental arch measurements. Males had higher mean values than females, but without statistical significance. The prevalence of dental arch forms across genders and dental arches is depicted in Table 2. The mid form predominated in arches and genders (83.33%). We observed low proportions of wide and narrow arch forms (<8.33 and 12.5%, respectively); gender differences were not significant.

4. Discussion

Numerous factors can influence the dental arch form, including genetics, ethnicity (race) and gender, along with environmental, occlusal, pathological, nutritional factors, orthodontic treatment, and general body stature [20]. The effect of genetics or hereditary variables on the formation of the dental arch is clearly evident, as is the case for Down's syndrome, cleft palate, and other craniofacial abnormalities [21]. In the present study, we enrolled healthy children with different socioeconomic statuses to eliminate the effects of these factors and to ensure the generalizability of our findings.

The ethnic element is crucial in determining dental arch forms and proportions. Researchers previously found that each human ethnic group has distinct dental arch traits and dimensions. Previous researchers compared Caucasoid, Mongoloid, Negroid, and Australoid ethnicities and clarified the presence of fundamental differences in dental arch size and shape between these different populations [22]. In contrast, clear differences in the arch dimensions between Mongoloid children and Dravidian children were reported by Smitha *et al.* [23], thus highlighting the need for baseline records for each population. In Iraq, there are many ethnic groups, including Arab, Kurd and Turkman. For the current study, we selected Iraqi Arabic samples to exclude the potential effect of ethnic factors.

The presence of undesirable oral habits, such as finger sucking, habitual mouth breathing, lip biting, or uneven muscle pressure, all represent environmental factors that can determine the dental arch form. The principal effect is to procline the maxillary anterior teeth and retrocline the mandibular anterior teeth, increasing the maxillary arch dimensions and reducing the mandibular arch dimensions [24]. The absence of poor oral habits was one of the major criteria for sample selection.

Patients with snoring, obstructive sleep apnea, or persistent problematic mouth breathing, were distinguished by a tapered arch form and severity based on the duration of the condition [25, 26]. In this study, children with respiratory issues were excluded in order to avoid these problems.

With regards to the role of an occlusal factor in determining dental arch forms, the course of the eruption of the teeth, their number, shape, size, and position, as well as the lengths and

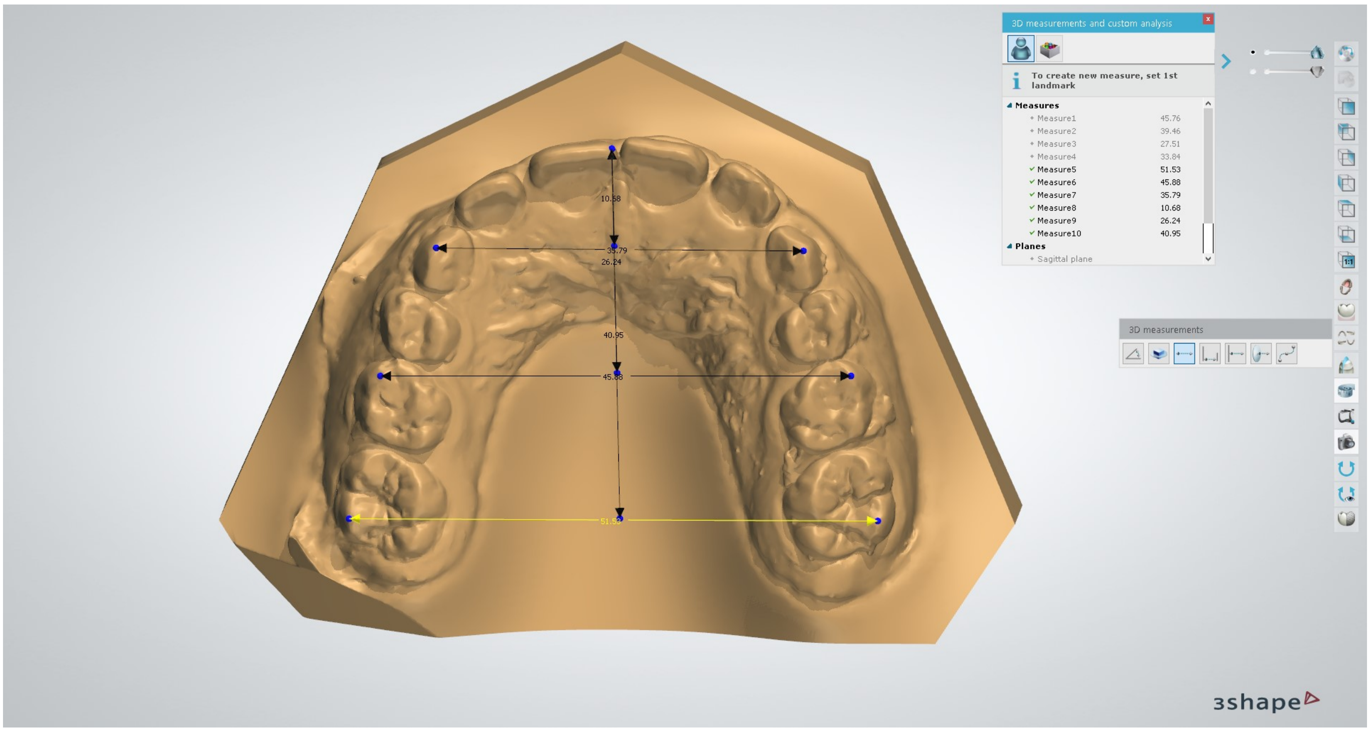

FIGURE 1. Maxillary dental arch widths and lengths measured *via* ortho analyzer software.

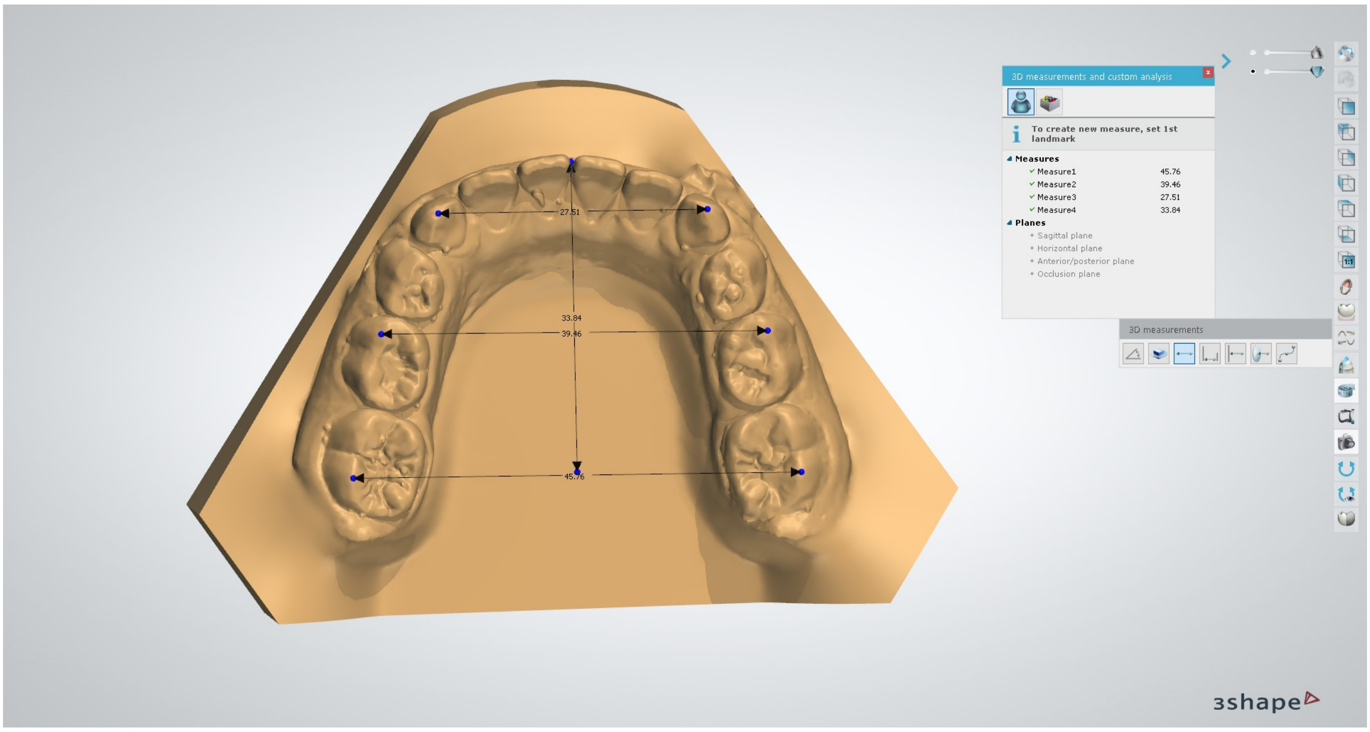

FIGURE 2. Mandibular dental arch widths and lengths measured *via* ortho analyzer software.

widths of the dental arch, are known to have a significant impact. Abnormal maxillary canine eruption or impaction has a significant impact on inter-canine width. In contrast, lateral incisors that are absent or palatally displaced might deform the arch shape [20, 24]. Skeletal and dental interarch relationships, as a type of malocclusion, also have influential effects on the arch form and this is particularly evident in class II divison 2 and class III [27]. Thus, we selected children with normal dentition.

Dental arch length is known to be significantly affected by bilateral inter-incisal distance and the mesiodistal crown width of the incisors, premolars and molars in both the maxilla and mandible. In addition, the mesiodistal crown width of the canines is known to influence the length of the dental arch in the jaw. The slope of the tooth axis also influences the dental arch. It has been reported that the slope of the buccal-lingual tooth axis in mandibular molars is primarily influenced by heredity; however, the influence of environmental factors can

TABLE 1. Descriptive statistics and gender differences for vertical and transversal measurements for both arches (S.D. = standard deviation).

Dental Arch	Measurements	Descriptive statistics				Gender difference	
		Males		Females			
		Mean	S.D.	Mean	S.D.	*t*-test	*p*-value
Maxillary							
	A	10.430	1.170	10.250	0.994	0.406	0.689
	B	33.207	2.386	33.163	1.879	0.050	0.960
	C	24.817	1.722	24.233	2.796	0.615	0.545
	D	45.316	1.656	45.038	2.484	0.322	0.751
	E	36.568	1.513	36.475	1.958	0.131	0.897
	F	52.305	5.389	52.204	1.445	0.063	0.951
Mandibular							
	A	7.825	0.955	7.805	1.360	0.042	0.967
	B	25.900	2.075	25.850	0.999	0.075	0.941
	C	22.989	2.840	22.925	2.961	0.054	0.957
	D	39.980	1.817	38.932	2.300	1.239	0.228
	E	35.033	2.052	34.858	1.256	0.251	0.804
	F	49.051	2.381	47.217	2.840	1.715	0.100

A: The perpendicular distance between the incisal point and inter-primary canine distance.
B: Inter-primary canine distance.
C: The perpendicular distance between the incisal point and inter-2nd primary molar distance.
D: Inter-2nd primary molar distance.
E: The perpendicular distance between the incisal point and inter-1st permanent molar distance.
F: Inter-1st permanent molar distance.
S.D.: standard deviation.

TABLE 2. Frequency distributions and percentages of dental arch forms in both genders and arches.

Dental Arch	Arch Forms	Genders			Gender difference		
		Males	Females	Total	Chi-squared	d.f.	*p*-value
Maxillary							
	Mid	10 (83.33%)	10 (83.33%)	20 (83.33%)			
	Wide	1 (8.33%)	1 (8.33%)	2 (8.33%)	0.000	2.000	1.000
	Narrow	1 (8.33%)	1 (8.33%)	2 (8.33%)			
Mandibular							
	Mid	11 (91.70%)	9 (75.00%)	20 (83.33%)			
	Wide	0 (0.00%)	1 (8.33%)	1 (4.17%)	1.533	2.000	0.465
	Narrow	1 (8.33%)	2 (16.70%)	3 (12.50%)			

increase progressively. Moreover, masticatory function, an environmental element, may influence the width of the dental arch. These findings show that arch widths may vary more amongst individuals based on their eating habits, preferences, and behavioral patterns [20, 28–31]. Orthodontic treatment can also affect the arch form, particularly in cases involving expansion of the upper arch [27]. Furthermore, increasing or decreasing the arch length orthodontically can also have an influential effect during the mixed dentition stage [10].

Based on three vertical and three transverse measurements, we determined the dental arch shapes of 24 dental casts belonging to healthy youngsters. Using Ortho analyzer software, we used scanned digital models to acquire appropriate measurements. Previous studies found no statistically significant difference between manual and automated measurements [32–34]. In general, males had greater mean values than females, although this was not a statistically significant observation. These findings were consistent with those reported previously by Louly *et al*. [35].

Numerous techniques can be used to determine dental arch shapes. Al-E'nizy [18] created the approach used in the present investigation, which was also utilized by Ahmed and Ali [19].

This procedure involves calculating the length-to-width ratio, obtaining the mean and standard values for each of the three ratios, and basing the arch form on the obtained value. The present study is the second study after Louly *et al*. [35] to determine dental arch forms at the mixed dentition stage; however, we used a more accessible dental arch form analysis than Louly *et al*. [35], who relied on Currier's technique [36]. We expected that the most dominant arch shape would be the mid form, given that our samples were taken from healthy children with no deviant behaviors or pathologies that could alter these characteristics. Similar to the study conducted by Louly *et al*. [35] on Brazilian children, we did not identify any significant gender differences in both jaws.

Despite the large age range in Sharaf *et al*. [37] study on Egyptian children and adolescents, our current findings relating to the main dental arch type are consistent with those reported by Sharaf *et al*. [37]. With the increased use of social media elements, such as Youtube and Instagram, many patients or parents have become aware of the effect of certain diseases on the oral cavity and teeth [38–40]. Distortion of dental arch forms by poor oral habits, chronic mouth breathing, or incorrect occlusal relationships, are often considered by parents when trying to address these issues in their children. Videos are often used to provide instructions for healthy teeth and general body organs to help minimize the detrimental effects that cause deterioration in the dental arch forms; such educational strategies are important in that early treatment may reduce the duration of side effects.

Normal occlusal relationships with caries- or restoration-free dentition is uncommon in children; thus, our sample size was the main limitation in this study. Future research must incorporate a larger sample size with various occlusal relationships and different body mass indices,

5. Conclusions

The middle dental arch form was dominant in healthy Arab children with mixed dentition in all genders and jaws. Hereditary factors may also play a major role in determing dental arch forms.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

DAAD, GC and MRAAK—designed the research study. MN—performed the research. MMM—analyzed the data. MC, MN and GM—wrote the manuscript. All authors provided editorial changes in the manuscript. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was conducted in accordance with the Declaration of Helsinki and the protocol was approved by the Ethics Committee of the Institute, University of Baghdad, Iraq (Protocol number: 169506; Date: 02/05/2021). The study protocol was developed and all subjects' parents were provided with a written informed consent for inclusion before they participated in the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Giuseppe Minervini is serving as one of the Editorial Board members of this journal. We declare that Giuseppe Minervini had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to NK.

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