Three dimensional analysis of dental arch form and dimensions in a sample of Kurdish students in Hawler Medical University

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Background: This study aims to use 3D analysis to compare male and female upper and lower dental arch forms in untreated Kurdish medical students, find differences in shape, transversal and longitudinal diameters between genders, and provide clinicians with a representative set of the population's dental arch to provide appropriate orthodontic treatment.

Methods: The sample consisted of 3D scans by the intra-oral scanner of maxillary and mandibular dental arches deriving from 111 Kurdish medical students (Male = 51, Female = 60) in permanent dentition. the arch form was evaluated by linear values and ratios by mathematical calculation on every patient using a 3shap ortho analyzer software .paired t-test and fisher's exact Test were used to determine if the differences in measurements between maxillary, mandibular, male, and female groups were significant. The level of significance was set at $P < 0.05$.

Results: There were significant differences in upper and lower transversal and longitudinal diameters. Male arch widths were significantly greater than female arch widths. In addition, males had significantly larger intercanine, intermolar, and interpremolar diameters than females. The female group had significantly less dental arch depth.

Conclusions: Based on the anatomical arches differences between genders in Kurdish students, it is suggested that each patient's pretreatment arch form, width, and depth during orthodontic treatment be considered according to gender.

Keywords: Arch form, Dental arch width and depth, intra-oral scanner, 3D analysis, 3D software

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Introduction

One of the primary goals of orthodontics has long been to achieve a stable, functional, and aesthetically pleasing arch form. Consideration of the arch form is critical because the arch form must be examined before beginning the treatment. This provides valuable information about the position of teeth that can be moved if they are stable after treatment. Several Orthodontists believe that a single form should be used for all malocclusions. According to orthodontists, the arch form is now adopted based on maximum function and is close to the perfect aesthetic. [1]

With the increased use of computers and advancing technology, custom-designing arch forms have grown in popularity. They may provide the best solution for accurately obtaining the ideal orthodontic arch form, thus catering to each individual's aesthetic and function. Dental arch dimensions, including width, length, and form, are critical values for the diagnosis, treatment, planning, and treatment outcomes of orthodontic patients of all ages. [2]

The dimensions and characteristics of the dental arch differ between ethnic groups and

populations. It is well known that the dimensions of the dental arch change during growth and development, but the changes slow down during adulthood. For this reason, studies tracking the evolution of dental arch size at different points in time have attracted the attention of numerous researchers. [3]

Dental arch studies are exciting for orthodontists to understand how occlusion changes during all stages of development. [4] The dental arch undergoes various dimensional changes with age, the greatest alterations taking place during the period of growth. [5] Several researchers attempted to categorize dental arch forms. The supporting bone configurations shape and confine the dental arch, which is influenced by tooth eruption and the surrounding muscular force. [6] This study aimed to assess the dental arch forms and detection most popular form in Kurdish population.

Methods

Study design and Data collection: A cross-sectional study of 135 medical students (males and females), with an age range of 18-25 years, were examined and scanned in randomly selected stages from different colleges of Hawler medical students. The stages were randomly selected from a list obtained from the registration unit of the College of Medicine, Dentistry, Pharmacy, Nursing, Maternity, Basic Medical Sciences, and Physiotherapy at Hawler medical university. Only One hundred and eleven Kurdish medical students (111 samples), including 51 males and 60 females aged between (18-25 years) fulfilled the following inclusion criteria. Twenty-four (24) samples were excluded because they did not fulfill the inclusion criteria.

Ethical approval: After receiving approval from the college of dentistry's ethical committee at Hawler Medical University, the study enrolled all patients who gave verbal and written informed consent.

Inclusion criteria: Kurdish students with age range between 0f (18-25) years old; class one malocclusion; in both arches, all permanent dentitions are fully erupted(except third molars)to the occlusal plane; no edentulous spaces in the dental arch; mild or no crowding and dental irregularities .

Exclusion criteria: mixed or primary dentition. Missing teeth. Dental anomalies; dental arches with significant transverse discrepancies ;retained deciduous teeth; incredibly crowded arches, history of medical complication, craniofacial malformation or syndromes, dental trauma; oral breathing pattern; previous orthodontic treatment; and or maxillofacial surgery ;prosthodontics restoration

Method : Upper and lower arches were scanned by the intraoral scanner (MEDiT I700) (figure 1), and digital bites were taken in ten minutes for each case. The scanner had four scanner autoclavable tips, for sterilization, a particular type of disinfectant (considering covid-19) was used to sterilize the tips. After processing data, the scanned upper and lower arches and their bites were kept at the MEDIT link program. Then the scanned arches were sent to 3shape Ortho Analyzer (figure 2) program, which took about 5 minutes.In the Ortho Analyzer program, each case must have a digital base for maxillary and mandibular arches and bite preparation. After this step, the scanned arches were ready for 3D analysis, including; the cusp tip of right and left permanent canines, the cusp tip of the mesiobuccal cusp of right and left first permanent molars. Incisal points of both permanent incisors detected.

Measurements: The distance between the tips of the right and left canine cusps is called the intercanine width (I.C.W.). The space between the upper right and left first molars, as measured from the top of the mesiobuccal cusps of the upper right and left first molars is called intermolar width (I.M.W.).

Canine depth (CD): distance between the midpoint of the upper and lower central incisors to the line joining the canines. The shortest distance from a line through the first molars back to the point where the two central incisors meet is the molar depth (M.D.). The ratio of intercanine width to canine depth (ICW/CD). the ratio of the inter-canine width to/ the canine depth. Inter molar width to molar depth ratio. Canine width/ molar width /canine depth/molar depth [(Wc/Wm) / (Dc/Dm)] (figure3).

Detection of the maxillary arch form: Cal-

culations were made using the formula [(Wc/Wm) / (Dc/Dm)] to determine the arch shape. The shape of the maxillary arch and how it relates to the occlusal pattern was calculated using the mean of the data collected on that arch . When the Wc/Wm ratio is raised or the Dc/Dm ratio is lowered, the arch is transformed into a square. In contrast, the arch narrows when the Wc/Wm ratio drops or the Dc/Dm ratio rises. To characterize the arch shape, the formula is applied (figure 4).If a dental arch's ratio is within the mean plus one standard deviation range, we know the arch shape is ovoid. However, when this ratio for an arch form is more than the mean plus one standard deviation, we can treat the arch as a square. When the ratio is smaller than the mean minus one standard deviation, the arch shape is said to be tapered (7)

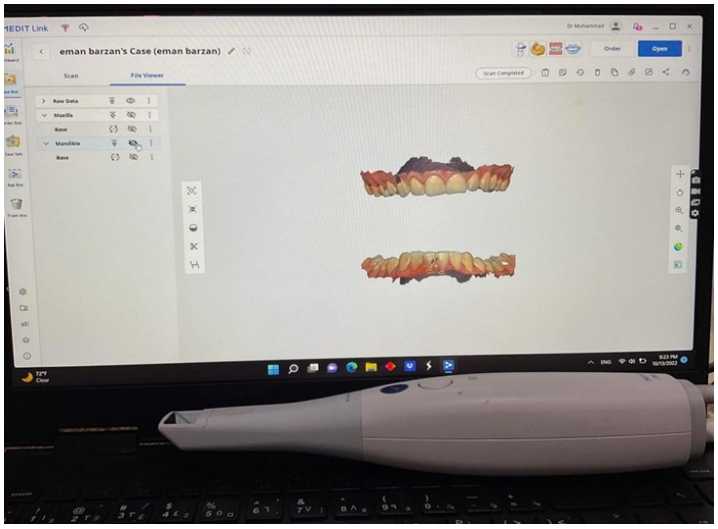


Figure 1: Intraoral Scanner Medit I 700&Special Laptop

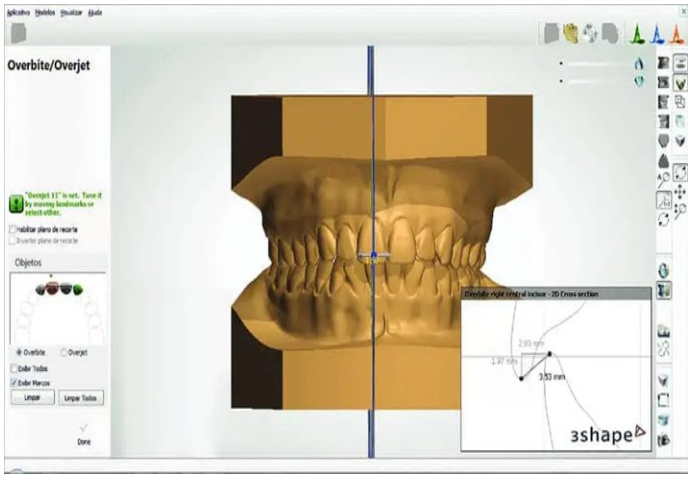


Figure 2: 3Shape Ortho Analyzer Software

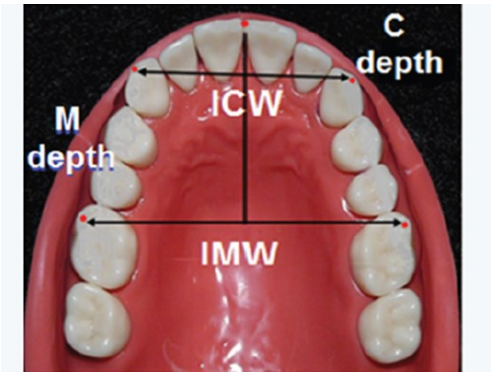


Figure (3): Intercanine Width, Canine Depth, Intermolar Width, And Molar Depth

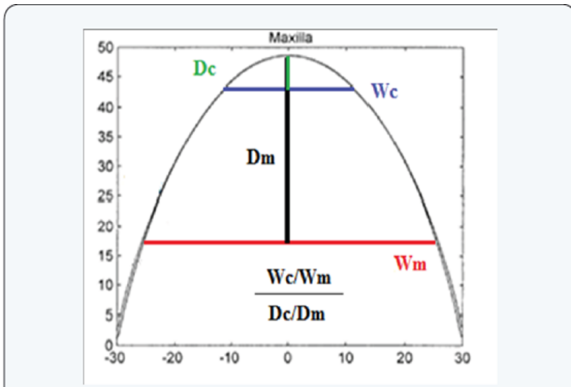
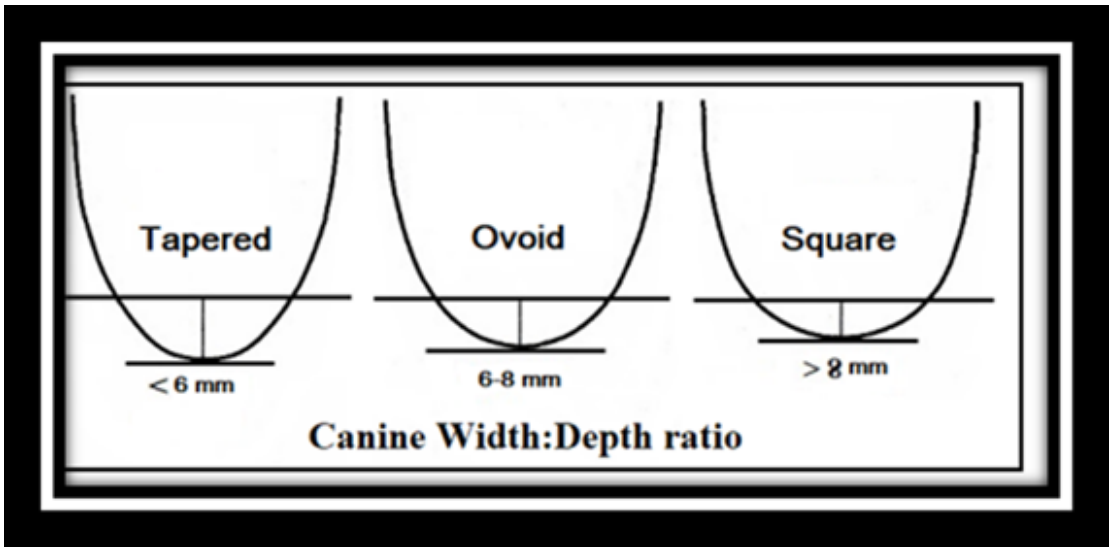


Figure (4): Mathematical method of arch form determination

Detection of the mandibular arch form: Raghda Al-Shammout is credited with establishing the arch shape among the Jordanians. Measures through which values are determined. A narrow arch form is presumed when the width-to-depth ratio of the canines (Figure 5) is less than 6. Arches can be considered ovoid if their depth is between 6 and 8 or square if it is greater than 8. [8]

Statistical analysis: Statistical analysis: All statistical values were analyzed using SPSS software (IBM SPSS Statistics for Windows, Version 26.0; I.B.M., Armonk, NY, U.S.A.). mean scores between sex and maxillary and mandibular arch measurements was compared by applying (Independent sample t-test), a (Fisher's Exact Test) was used to test the independence between of maxillary and mandibular variables



Figure(5): Method For Mandibular Arch Form Detection

Results

A total of (111) individuals were included in this study, mean age of 21.08 with SD 2.046; among them (51) were males and (60) females; the samples were divided into the ovoid, taper, and square arch forms as in table one which illustrates the frequency distribution of three forms among whole samples, It was found that 41 arches(36.9%) were ovoid, six arches(5.4%) were taper, and four arches (3.6%) were square form.

This is for maxillary arches in male individuals, while in females, the result shows 48 arches(43.2%) were ovoids, eight arches (7.2%) were taper, and four arches (3.6%) were square.

Table 1: Shows the frequency distribution of upper and lower arch forms according to genders

		Male		Female		Fisher's Exact Test (p-value)
		N	%	N	%	
Arch_U	Ovoid	41	36.9%	48	43.2%	2.423 p(0.345)
	Taper	6	5.4%	8	7.2%	
	Square	4	3.6%	4	3.6%	
Arch_L	Ovoid	33	29.7%	41	36.9%	0.200 p(0.534)
	Taper	10	9.0%	15	13.5%	
	Square	8	7.2%	4	3.6%	

Table 2: mean and standard deviation with t-test of arch dimensions and ratios between males and females.

		Mean ±SD	t-value	p-value
UICW	Male	36.35 ± 1.5	2.297	0.024*
	Female	35.52 ± 2.19		
LAW	Male	28.56 ± 1.59	1.674	0.097
	Female	28.04 ± 1.65		
UCD	Male	5.91 ± 0.74	0.033	0.974
	Female	5.9 ± 0.75		
LCD	Male	4.4 ± 0.58	0.283	0.778
	Female	4.37 ± 0.55		
UIMW	Male	52.69 ± 3.11	3.892	0.000**
	Female	50.68 ± 2.31		
LIMW	Male	46.12 ± 3	2.807	0.006**
	Female	44.68 ± 2.4		
UMD	Male	27.58 ± 2.28	2.400	0.018*
	Female	26.59 ± 2.08		
LMD	Male	24.94 ± 2.35	3.510	0.001*
	Female	23.48 ± 2.04		
CW/CD up	Male	6.19 ± 0.83	0.667	0.506
	Female	6.09 ± 0.73		
CW/CD L	Male	6.62 ± 1.04	0.583	0.561
	Female	6.51 ± 0.93		
MW/MD U	Male	1.89 ± 0.31	-0.558	0.578
	Female	1.92 ± 0.15		
MW/MD L	Male	1.87 ± 0.21	-0.921	0.359
	Female	1.88 ± 0.22		
CD/MD	Male	0.21 ± 0.03	-1.111	0.269
	Female	0.22 ± 0.02		
CW/MW	Male	0.69 ± 0.04	-0.613	0.541
	Female	0.7 ± 0.05		
(CD/MD)/CW/MW	Male	0.31 ± 0.05	-1.214	0.228
	Female	0.32 ± 0.05		

Table 3: mean and standard deviation with t-test of arch measurements between maxillary and mandibular

		Mean ±SD	n	t-value	p-value
Pair 1	UICW	35.9 ± 1.94	111	38.458	0.000**
	LAW	28.28 ± 1.64	111		
Pair 2	UCD	5.91 ± 0.74	111	23.328	0.000**
	LCD	4.38 ± 0.56	111		
Pair 3	VIEW	51.6 ± 2.87	111	30.600	0.000**
	LIME	45.34 ± 2.77	111		
Pair 4	UMD	27.04 ± 2.22	111	12.657	0.000**
	LMD	24.15 ± 2.3	111		
Pair 5	CW/CD U	6.14 ± 0.77	111	-4.725	0.000**
	CW/CD L	6.56 ± 0.98	111		
Pair 6	MW/MD U	1.9 ± 0.24	111	1.063	0.290
	MW/MD L	1.87 ± 0.21	111		
** Significant at level (p<0.01)					

Discussion

For an accurate diagnosis, treatment planning, treatment strategy, and post-treatment stability, measuring arch dimensions and defining arch shapes before orthodontic treatment are mandatory stages. [9]

Choosing the proper arch form for correcting malocclusion is essential for a healthy, beautiful bite. Once the patient's pretreatment arch form has been established, it is clinically appropriate to offer a variety of executed arch forms from which to select. [10]

The arch shape is mainly set by age nine, with intercanine and intermolar width being the most critical factors. during mixed dentition, in particular, the dental arch is rapidly enlarged. On the other hand, modern orthodontic procedures also cover the lower second molars. Regarding average arch-width alterations following the eruption of the second molars, the reported results were inconsistent . arch width changed by less than one millimeter during adolescence. Using the incisal edges and cusp tips as markers. [11]

Many traditional investigations used untreated standard samples to statistically determine the arch shape or characterize arch form using various metrics. [12]

This research aimed to characterize the typical dental arch morphology of a non-consulting Kurdish population for angle class one. Many researches involving various populations have been completed. However, sincethe mandible is used as a benchmark for orthodontic diagnosis and treatment, most studies focused on that structure. [13] According to many authors, the stability of the shape and size of the mandibular dental arch is crucial for predicting the stability of the outcomes. Only a little research concentrated on the maxillary arch. [14]

This study assessed the dental arch form using 3shape Ortho Analyzer software. It is more accurate, more accessible, and less time-consuming.

Different investigators have described and discussed various landmarks; however, no universal agreement has been reached on determining dental arch width. [15] The dimension of the arch across the permanent canines, premolars, and first molars, at the cusp tips, central fosse, or contact points, or the most significant distance between buccal surfaces, was used in most studies. [16,17]

The most famous landmarks have been selected to be used in this study to enhance the comparison with other different studies on different ethnic groups, including the cusp tip of permanent canines, cusp tips of the

mesiobuccal cusp of first permanent molars, incisal point(origin between the central incisors).[18] In 1932, Chuck categorized arch shapes into square, ovoid, and tapering. After years of usage by researchers and clinicians, this categorization was adopted by orthodontic manufacturers to inform the design of arch shapes. More customization is possible in the early archwire phases using a three-arch form technique instead of a single-arch form approach. [19]

In this study, three arch forms were identified, as in maxillary arch forms. About 89 individuals (80.1%) were ovoid, of which 41 (36.9%) were male, 48 (43.2%) were females,14 (12.6%) samples were taper in which 6 (5.4%) were male,8 (7.2%) were female, last 8 (7.2%) samples were square in that 4 (3.6%) were male 4 (3.6%) were female.

While in mandibular arches, about 74 (66.6%) samples were ovoid. In that finding, 33(29.7%) cases were male,41 (36.6)% cases were female,25(22.5%) individuals were taper in which 10(9.0%) cases were male,15(13.5%) cases were female, last 12 (10.8%)individuals were square 8(7.2%) of that samples were male, and 4 (3.6%)were female. In this study, as mentioned above, ovoid arch forms were more in maxillary arch form as compared to lower mandibular arch forms, the maxillary arch forms were divided as ovoid, which was more than taper, and square, which was least one, but females had more ovoid arch forms as compared to males, and had more taper forms than males. Finally, both males and females had equal square forms. while in mandibular arches, females had more ovoid and taper forms than males, square arch forms were more in males than females.

The cusp tips of canines are used in this study to measure intercanine width. In addition, the mesiobuccal cusp tips of the first molars are used to measure the intermolar width of the maxillary and mandibular arch.

Results from this study demonstrated that arch dimensions varied by gender. When comparing arch dimensions between sexes, men were found to have significantly larger arches. However, those results come from an older study. Arch measurements are analyzed for width and depth. It has been reported that the maxillary inter canine width and depth were higher for males than females, and there was a statistically significant difference between them (p=0,024). In contrast, mandibular intercanine width and depth were the same between genders and statistically insignificant. Therefore, maxillary and mandibular canine depth were statistically insignificant .it means there was no gender-related measurement between them.

Intermolar width and depth were gender-related measurements as maxillary and mandibular intermolar width and depth for males and females were statistically highly different (P=0.000,0.006, respectively). It turned out that males have wider arches compared to females. In addition, while the molar depth of maxillary and mandibular arches was gender-related, as there were statistically significant differences between males and females, males have more prominent arches than females.

In the present study, the comparison between maxillary and mandibular arch measurements was done, as In maxilla, the arch width and depth are higher than mandibular measurements as maxillary arch depth and width were statistically significant differences, including intercanine width, canine depth, intermolar width, and molar depth. (p=0.000)

Moreover, the canine width/depth ratios between the maxilla and mandible were highly statistically significant, .it means the maxilla is wider and larger than the mandible, and there is a statistically confirmed difference between them. However, molar ratios (molar width /depth ratio) were statistically non-significant(p=0.290).

Conclusion: The following conclusions can be summarized:
Kurdish males have a larger transversal and longitudinal dimension of both arches than females. Dental arch form statistically non-significant differences between the genders. Due to anatomical arch differences between genders. It is recommended that each patient's pretreatment dental arch form, width, and depth be considered by gender during orthodontic treatment.

Conflict of interest
The author reported no conflict of interests.

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