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Arch Form and Dimensions of Sudanese Adults with Normal Occlusion

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Abstract

Background:

In contemporary orthodontics for the accessibility to the orthodontists, and comfort of the patients the use of preformed archwires become popular. The shape of preformed archwires, especially superelastic nitinol wires cannot be changed easily. Hence, the choice of the arch form of the mandibular dental arches has become essential when using these elastic arches.

Objective:

To analyze the mandibular dental arch forms of Sudanese adults and to compared gender difference among the Sudanese samples.

Materials & Method:

Transverse and sagittal dimensions on dental stone models of 104 Sudanese adults aged 16- 26 years with normal occlusion were measured using standardized Boley gauze. The analysis was done according to Raberin's mathematical sixth degree polynomial method.

Result:

The distribution of the Sudanese arch forms types were, 73.1% mid arch, 10.6 % narrow arch, 8.7 % wide arch, 3.8 % flat arch and 3.8 % pointed arch.

Conclusions

The analysis enables the mathematical method that predetermines the dental arch form of the individual orthodontic patient.

Key words: arch form, polynomial, sagittal, Sudanese, transverse

Introduction

In contemporary orthodontics for the ease and perfection to the orthodontists preformed arch wires have gained acceptance. Furthermore, with the use of advances materials, and the use of elastic arch wires, the choice of the form of the mandibular dental arches has become vital (1).

Form and dimensions of the mandibular dental arch is a factor of stability of the therapeutic results (2). It is known that the mandibular arch has different shapes in different people though each one has normal occlusion. Many factors predispose to differences in mandibular arch form and it is believed that during orthodontic treatment procedures, one must not try to alter the original arch form to have stable results (3).

Some orthodontist tend to individualize the arch form to respect the original mandibular inter-canine width during treatment, by using arch guides(4-6) or by a computer- assisted determination of an ideal dental arch form (7).

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The geometric curve associated with mandibular dental arch form was studied by different researchers. The concept of a circular form of the anterior part of the arcade(8, 9) has been taken up by some authors in the straight wire techniques(10) as well as by the occlusodontists(11). Catenary curves are seen in the deciduous dentition(12). Some studies assumed that adult are presented with same features(13, 14). Brader, (4) postulated the concept of a trifocal ellipse based on the balance between antagonist muscles takes into account functions as essential morphologic factors of the mandibular arcade.(4)

Many researchers studied dental arch form using polynomial curves. Lu (15), expressed fourth degree orthogonal polynomial curve to represent dental arch. Ferrario et al,(16) examined arch shapes by fourth order polynomial and mixed elliptical and parabolic interpolation. Ferrario et al,(17) used Euclidean distance matrix for arch form analysis. Begole et al,(18) established the method using cubic spline function to model the dental arch form.

Raberin et al,(1) in 1993 determined dental arch forms of untreated French adults with normal occlusion. They considered measurements of the mandibular arch and the ratios of the dimensions to develop a classification system of the dental arch. They used a polynomial function equation of the sixth degree, that enable a curves to be traced through the reference points.

Dental arch variations exist among different racial groups(19). So, ethnic differences in arch dimensions and form should be considered during orthodontics treatment.

The present work aims to study the dimensions and forms of the normal mandibular dental arch in Sudanese adult, to establish norms that could be applied to the orthodontic diagnosis and treatment planning of the Sudanese orthodontic patients and to develop a classification system of arch forms easy to put into clinical practice.

Materials & Methods

This descriptive analytical, cross-sectional study, was carried out in the capital city of Republic of Sudan (Khartoum), for university students of Al- Neelain University.

The samples included 104 mandibular dental casts of the Sudanese adults aged 16-26 years with equal male to female ratio.

The study sample was calculated by the following equation:

$$n=(\frac{ZS}{e})^2 deff$$

Where:

z= 1.96 for 95% confidence level.

e = margin of error in mean (5% of the mean)

deff=2

Mean and standard deviation was obtained from previous study (20)

as follow: SD=3, mean =23.8.

e= 0.05*23.8

$$n= \frac{1.96^2*3^2}{(0.05*23.8)^2} *2 =52$$

the sample size almost equal to 52. The overall sample become 104 (52 males and 52 females).

The samples were selected according to the inclusion criteria of normal occlusion with full complement of permanent teeth (with or without third molars), Class I canine and molar relation, symmetrical dental arch, normal over jet and over bite (2mm±1mm) and no previous orthodontic treatment.

Ethical Approval was obtained from Central Institutional Review Board in Al- Neelain University. Written consent was obtained from the students participated in this study. Students were free to participate or refuse participation even if they met all of the criteria necessary.

The standardized Boley gauge of 0.01 millimeter accuracy (0-150 mm /6" X0.01 JAPAN) was used to measure the dimensions.

Dental arch forms were analyzed according to the method described by Raberin's et al (1). The transverse and sagittal measurements of the dental arches were determined on mandibular casts. The reference points were determined as; mid-incisal edge on the labial side, canine cusp tips, mesio-buccal cusps of first molars and disto-buccal cusp tips of second molars.

The transverse measurements:

- Inter-canine width (L33) between the canine tips.
- Mean inter-molar width (L66) between the mesio-buccal cusps of the first molars

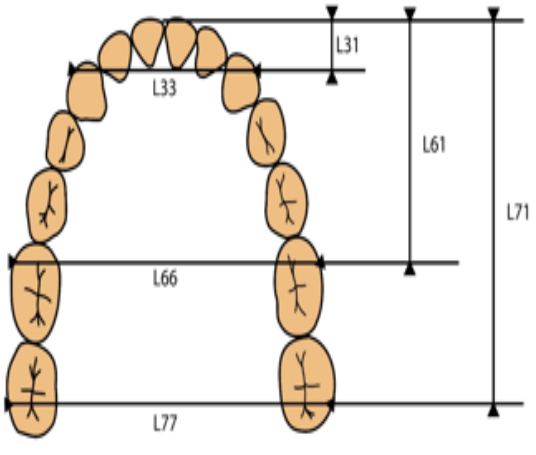
- Posterior inter-molar width (L77) between the disto-buccal cusps of the second molars.

The sagittal measurements:

- Canine depth (L31) from the mid-incisal edge to the line joining the cusp tips of the canines
- Mean arch length (L61) from the mid-incisal edge to the line joining the mesio-buccal cusps of the first molars.
- Total length (L71) from the incisal edge to the line joining the disto-buccal cusps of the second molars.

Six transverse and sagittal dimensions characterize both the form and dimension of the dental arch (Figure 1).

Figure 1: Transverse and sagittal measurements in mandibular cast



The five independent ratios that determined the arch forms were; L31/L33, L61/L66, L71/L77, L33/L66, and L61/L71.

The independent ratios were computed for all samples and relative deviation between the mean value of a given ratio for a given form and mean value of the same ratio for the whole sample were computed to distinguish the five dental arch forms of the Sudanese samples in graphical representation.

Relative deviation =

$$\frac{\text{Mean value of given sample} - \text{Mean value of the whole sample}}{\text{Mean value of the whole sample}}$$

Statistical analysis was carried out using SPSS 20 analytic software.

Both Kolmogorov-Smirnov and Shapiro tests were provided to check normality of data. Student's t-test was used to compare the difference between the arch dimensions of male and female subjects. Significance was set at the 5 % level ($p \leq 0.05$).

Result:

All data were normally distributed, this was tested by Kolmogorov-Smirnov and Shapiro –Wilk tests.

Transverse and sagittal dimensions of the mandibular dental arch of combined male and female subjects are shown in Table 1.

Table 1: Dimensions (in mm) of the mandibular dental arch (n= 104)

Dimensions	Mean	Std. Deviation	Minimum	Maximum
Transverse				
L 33	27.97	1.65	23.30	32.20
L 66	46.88	2.49	40.60	53.60
L 77	55.46	3.16	48.50	63.10
Sagittal				
L 31	6.08	1.16	3.70	10.50
L 61	25.22	1.96	19.80	29.10
L 71	40.92	2.62	33.60	47.90

Transverse and sagittal dimensions for male and females was shown in Table 2, transverse dimensions of males were greater than female, statistical significant difference were noted in all dimension except (L31) and (L61).

Table 2: Dimensions (in mm) of the mandibular dental arch by gender (n= 104)

	Male (n=52)		Female (n=52)		P-Value
Dimensions	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**	
Transverse					
L 33	28.43	1.58	27.51	1.61	0.004
L 66	48.09	2.41	45.67	1.94	<0.001
L 77	57.08	2.98	53.84	2.43	<0.001
Sagittal					
L 31	6.08	1.19	6.07	1.14	0.961
L 61	25.32	1.95	25.12	1.98	0.591
L 71	41.67	2.57	40.18	2.47	0.003

* Significant at $p \leq 0.05$

The correlation coefficient was carried out between arch widths and lengths, some of them showed high significant, positive and direct relations, while others showed moderate, weak relationships. The correlations were clearly prominent and stronger between L33 and L66 length with other arch dimensions as shown in Table 3.

Table 3: Correlation matrix of the arch dimensions (n=104)

		Transverse			Sagittal		
Dimensions		L 33	L 66	L 77	L 31	L 61	L 71
Transversal							
L 33	Pearson Correlation	1.00	.562**	.492**	.303**	.577**	.572**
	P-Value		.000	.000	.002	.000	.000
L 66	Pearson Correlation		1.00	.785**	.174	.289**	.398**
	P-Value			.000	.077	.003	.000
L 77	Pearson Correlation			1.00	.109	.189	.285**
	P-Value				.269	.054	.003
Sagittal							
L 31	Pearson Correlation				1.00	.475**	.521**
	P-Value					.000	.000
L 61	Pearson Correlation					1.00	.818**
	P-Value						.000
L 71	Pearson Correlation						1.00
	P-Value						

**Correlation is significant at the 0.01 level (2-tailed).

The classification of arch form was based on five independent ratios of the predetermined arch dimensions Table 4.

Table 4: Mean and SD of the five ratios

	Mean	Std. Deviation
L31/33	.217	.040
L61/66	.539	.043
L71/77	.740	.054
L33/66	.597	.032
L61/71	.616	.028

Determination of arch form for individual case:

Depending upon negative or positive of each ratio from it is overall mean value, the arch form of particular case is decided by Raberin's(1) method. Based on the five independent ratios, the arch forms were classified as;

Form 1 Narrow: 3 sagittal/transverse ratios are positive

Form 2 Wide: 3 sagittal/transverse ratios are negative

Form 3 Mid: None of the ratios significantly deviates from the average

Form 4 Pointed: Only L31/L33 ratio has the intensity higher than the average

Form 5 Flat: Only L31/L33 ratio has the intensity below the average

According to this, five arch forms were distinguished as narrow, wide, mid, pointed and flat Table 5.

Table 5: Mean and SD of the five ratios in each type of arch forms

Arch Form	Ratio L31/33		Ratio L31/33		Ratio L31/33		Ratio L31/33		Ratio L31/33	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Narrow	.2518	.02798	.5994	.02580	.8191	.01996	.6209	.02941	.6334	.01686
Wide	.1804	.02726	.4648	.02143	.6557	.02768	.5652	.01736	.6008	.01854
Middle	.2130	.02449	.5377	.03376	.7383	.04399	.5978	.02983	.6148	.02888
Pointed	.2691	.01283	.5669	.01480	.7511	.01798	.5768	.02423	.6345	.01483
Flat	.1565	.01383	.5326	.03456	.7211	.05595	.6144	.04008	.6140	.02928

Relative deviation between the mean values of a given ratio for a given form and the mean value of the same ratio for the whole sample was computed and it represented in graphical form in Figure 2.

Figure 2: Relative deviation for each form of each ratio from its overall mean value

According to the present study; 73.1% of the Sudanese adults possess mid dental arch form, 10.6% narrow, 8.7% wide arch form, 3.8% pointed arch form and 3.8% flat arch form Table 6.

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Table 6: Distribution of dental arch form in Sudanese sample

Arch form type	Female		Male		Total	
	N	%	N	%	N	%
Narrow	7	13.5	4	7.7	11	10.6%
Wide	4	7.7	5	9.6	9	8.7%
Middle	38	73	38	73	76	73.1%
Pointed	2	3.9	2	3.9	4	3.8%
Flat	1	1.9	3	5.8	4	3.8%
Total	52		52		104	

Discussion

This study included young adult subjects, the mean age was 19.5±2.2 yrs. According to studies in arch width growth changes, inter canine and inter molar widths did not change after 13 years in females and 16 years in males so it was assumed that the widths in this group of sample were stable and expected to have passed their active growth phase, therefore, had stable arch widths(21, 22) In our sample all 104 subjects had class I normal occlusion, the reason of this is to eliminate variations that are likely to occur due to change in dentoalveloar skeletal pattern in class II and III malocclusions (23, 24).

This study includes equal number of the both genders so direct statistical comparison between groups were possible.

The present work studied the dimensions of the normal mandibular dental arcade, since the mandibular dental arch is considered very important for diagnosis and treatment planning in orthodontics, its consistency in form and dimension is a factor of stability of treatment results(25).

Sagittal and transverse measurements of the mandibular dental arch were taken from the reproducible reference points. Raberin's (1) found strong correlation between these reference points. According to Raberin's(1), these points constitute the landmarks that define breaking points of the mandibular arch that limit sectors on which different muscle groups act.

Previous literatures and studies on dental arch shape used conventional anatomical points on the incisal edges and molar cusp tips, etc. in order to classify dental arch forms by means of various mathematical forms(2), such as spline curves(26), and the beta function(2). Despite their biological significance, conventional anatomic points do not provide clinical evidence of appropriate archwire blank forms. On the contrary, landmarks taken on the vestibular surface of the teeth facial axis points (FA points) give direct representation of clinical arch wire shape(27) as these correspond fairly to the position of the brackets for straight wire therapy.

The transverse measurements we observed in our sample, inter-canine and inter-molar widths, gave values higher to values found in other studies(1, 3, 28, 29) conducted in samples defined according to the same criteria Table 7. The reason for this finding might be due to difference in the population of the sample and the ethnic groups.

Table 7: Comparison of arch dimension among Sudanese and other racial groups.

Dimension	Sudanese Present study	French (Raberin's) (1)	Nepalese(28)	Gujarati(3)	Yemeni(29)
Transverse					
L33	27.97	25.8	25.48	26.06	25.32
L66	46.88	45.3	45.66	45.18	44.02
L77	55.46	54.1	53.66	54.46	51.83
Sagittal					
L31	6.08	5.5	5.28	5.89	5.09
L61	25.22	23.7	22.99	24.27	24.93
L71	40.92	39.6	37.73	39.81	38.36

In most studies (1, 3, 28, 29), the arch dimensions depend on the sex of the subjects, with smaller values in women. Our results are in the line of these studies.

The relationships between the inter-canine and inter-molar widths had the same intensity as in the investigations of Raberin's(1) (correlation of 0.562 versus 0.58 respectively).

Since Angle, orthodontists have tried to determine a single, ideal arch form that can ensure the stability of the therapeutic results(1) . Our findings confirm that the ideal dental arch has no single and universal form, but that there are at least five different forms among the most frequently seen in Sudanese untreated adults with normal occlusions Table 6.

When comparing the results of the present study with the results of Raberin's(1) on French adults Table 8, the study shows that the distribution of arch form types is different

in two population groups. The narrow arch form is the most predominant type in Caucasians (23.7%) while it stands as the second predominant group among the Sudanese (10.6%). On the other hand, mid arch is the fourth predominant type in Caucasians (18.7%) while it stands as the most predominant group in Sudanese samples (73.1%). These facts could be attributed to racial variations in dental arch forms and dimensions among the population groups.

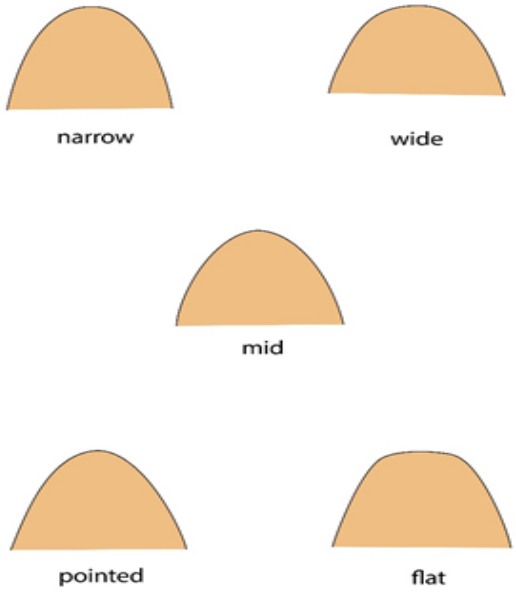
When comparing the distribution of arch forms in Sudanese adults with those of the Nepalese(28), Gujarati(3) and Yemeni(29) population groups Table 8, the present study shows that the arch forms are predominated by the mid type in Sudanese samples while flat types are predominant in Nepalese, wide are predominant in Gujarati and narrow predominant in Yemeni samples.

Table 8: Comparison of types of arch form among Sudanese and other racial groups.

Type of arch form	Sudanese Present study	French Raberin's(1)	Nepalese(28)	Gujarati(3)	Yemeni(29)
Narrow	10.6%	23.7	18	17.5	30.9
Wide	8.7%	19.7	24	26.4	23.9
Middle	73.1%	18.7	13	22.8	9.3
Pointed	3.8%	19.4	19	15.8	17.6
Flat	3.8%	18.3	26	17.5	18.3
Total	104	278	100	57	398

Figures 2 and 3 show the various types of arch forms derived from the mean values of various parameters of different type for Sudanese population. This may help us to correlate the arch form of an individual and accordingly we can select the preformed archwire of proper shape and dimension for the better and efficient diagnosis and treatment of an individual. In order to identify patient's arch form first find out the five ratios and calculate their percentage relative deviation from the overall mean as shown in the Table 4 and matching the closest readings of percentage relative deviation with the finding shown down in Figure 2, individual's membership to one of the five arch form group can be determined.

Figure 3: Arch guide of mandibular dental arch (according to mean arch dimensions of each form)



Conclusion:

The arch form analysis of the Sudanese adults was based on the mathematical method developed by Raberin et al which classified the mandibular dental arch into five morphological types. The most prevalent form is the mid form in both male and female samples

Conflict of Interest

There is no conflict of interest.

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