

Clinical measurements of the dimensions of the dental arches and its application on construction of dental prosthesis

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ABSTRACT

Aims: To determine the ideal dimensions of the artificial dental arch by measuring the dimensions of dental arch of completely dentulous subjects and to find the relation of these dimensions to some facial measurements. **Materials and Methods:** The sample of study consisted of 54 completely dentulous adult subjects (24 females and 30 males) with Class 1 normal occlusion aged 19–24 years. Dental casts were taken for each subject and the dimensions of the dental casts and the facial measurements were made by using digital vernier caliper. The data were analyzed with Statistical Package for Social Science program. **Results:** The dimensions of the dental arches and the facial measurements of the male group was larger than that of female and there was high correlation between some dimensions of dental arch with some of the facial measurements. **Conclusions:** The width of the dental arches of the artificial dental prosthesis could be determined depending on the extraoral facial measurements as the percentage of upper intercanine distance to mouth width is 74.43% and the percentage of the upper inter first molar distance to bizygomatic width was 40.65%

Key Words: Dental arches, facial measurements, dental prosthesis.

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INTRODUCTION

Complete dentures are artificial substitutes for living tissues that have been lost. The denture must replace the form of living tissues as closely as possible and it must importantly functions in harmony with the remaining tissues that both support and surround them. Changing the shape and position of the artificial dental arches away from the natural arches causes highly unsatisfactory loss of face form and expression with inadequate function of the artificial prosthesis.⁽¹⁾

The shape and size of the alveolar ridges change when natural teeth are removed. After the extraction of the teeth, bone reduction usually occur in the labial and buccal area of residual ridges. Consequently, the maxillary residual ridge is palatal to the original location of the natural teeth and the mandibular ridge is buccal to it. The maxillary artificial teeth, therefore, should be placed labial and buccal to the residual edentulous ridge if they are to be placed in the neutral zone and produce harmonious function with the remaining tissues, a step which complicates the classic

arrangement of artificial teeth on the residual ridge.^(1, 2)

The purposes of this study were directed to establish the normative values of the maxillary and mandibular dental arch dimensions and to find the percentage of these dimensions to some of the facial measurements in an attempt to establish normal baseline data which have a valuable importance to prosthodontists that facilitate the accurate arrangement of the artificial teeth in an ideal dental arch dimensions that are closely related to some facial measurements of each individual patient.

MATERIALES AND METHODS

The sample of this study consisted of 54 subjects (24 females and 30 males) aged from 19 to 24 years. The criteria for selection were the presence of 28 to 32 permanent teeth in an ideal alignment with Class 1 normal occlusion, no previous orthodontic treatment, no artificial crown present and no restorations replacing the incisal edge of anterior teeth or buccal cusps of posterior teeth.

Measurements were made on dental

models of the subjects after taking the impression of maxillary and mandibular dental arches with perforated tray using alginate hydrocolloid impression material (Ortho alginate, Denturum, Germany). All the measurements were carried out using electronic digital vernier caliper (LEZACO, ART, 2771, 0–150 mm accuracy, China).

Twenty linear measurements were made on the study models of maxillary and mandibular dental arches to determine the width and the length of them (Figure). The linear measurements included the followings: ⁽³⁻⁵⁾

- 1-Intercanine distance (C–C): The linear distance between the cusp tip of the right and left canines.
- 2-Inter first premolar distance (P1–P1): The linear distance between the buccal cusp tip of the right and left first premolars.
- 3-Inter second premolar distance (P2–P2): The linear distance between the buccal cusp tip of the right and left second pre-

molars.

- 4-Inter first molar distance (M1–M1): The linear distance between the mesiobuccal cusp tip of the right and left first molars.
- 5-Inter second molar distance (M2–M2): The linear distance between the mesiobuccal cusp tip of the right and left second molars.
- 6-Canine vertical distance (1–C): The linear distance from incisal point perpendicular to C–C distance.
- 7-First premolar vertical distance (1–P1): The linear distance from incisal point perpendicular to P1–P1 distance.
- 8-Second premolar vertical distance (1–P2): The linear distance from incisal point perpendicular to P2–P2 distance.
- 9-First molar vertical distance (1–M1): The linear distance from incisal point perpendicular to M1–M1 distance.
- 10-Second molar vertical distance (1–M2): The linear distance from incisal point perpendicular to M2–M2 distance.

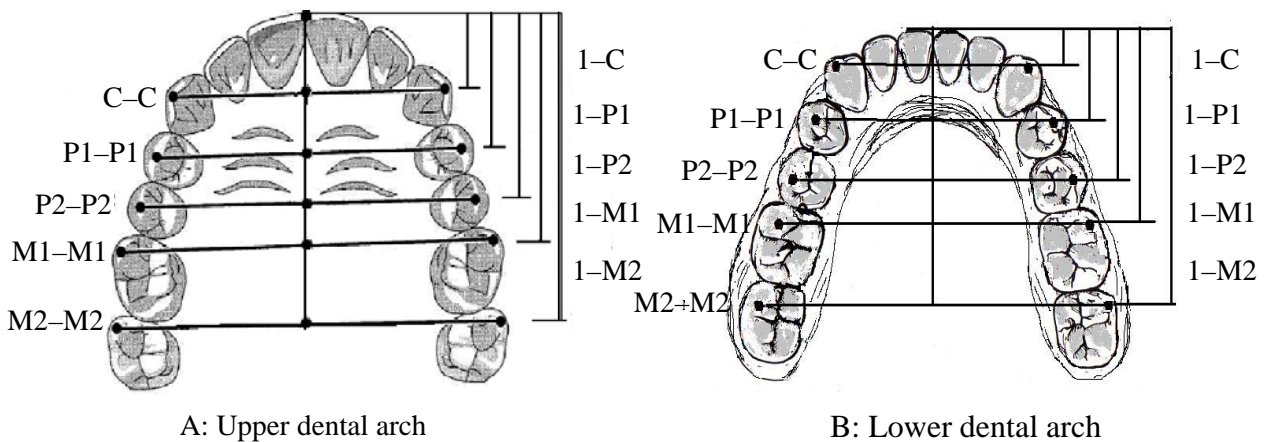


Figure: Dimensions of the upper (A) and lower (B) dental arches

C–C: Intercanine distance, P1–P1: Inter first premolar distance, P2–P2: Inter second premolar distance, M1–M1: Inter first molar distance, M2–M2: Inter second molar distance, 1–C: Canine vertical distance, 1–P1: First premolar vertical distance, 1–P2: Second premolar vertical distance, 1–M1: First molar vertical distance, 1–M2: Second molar vertical distance.

Regarding facial measurements, each individual was seated in an upright and relaxed position. The following distances were measured:

- 1-Interalar width (IAW): The linear distance between the two alae of the nose.
- 2-Mouth width (MW): The linear distance

between the two angles of closed mouth at rest state.

- 3-Interpupillary distance (IPD): The linear distance between the pupils of eyes.
- 4-Bizygomatic width (BZW): The maximum linear distance separating the two zygions which is called the bizygomatic

width was measured. Zygion is the most lateral point of zygomatic arch or cheek prominence.⁽⁶⁾

The recorded data of the study sample were analyzed with Statistical Package for Social Science (SPSS) program which included mean, standard deviation, minimum and maximum values computed for each variable. Student's t-test to make comparison for male and female, the correlation coefficient between the variables and finally the percentage of significantly correlated variables were obtained.

RESULTS

The dimensions of the maxillary and mandibular dental arches (width and length) were obtained. Table (1) illustrated the descriptive statistics of maxillary and mandibular dental arches dimensions for total sample including: Mean, minimum and maximum values with standard deviation. All the dimensions of mandibular dental arch including width and length were smaller than the corresponding dimensions in maxillary dental arch.

Table (1): The descriptive statistics of dental arch dimensions

Variables	Width							
	Upper				Lower			
	Minimum	Maximum	Mean	± SD	Minimum	Maximum	Mean	± SD
C-C	28.85	41.06	34.6307	2.4082	20.98	30.43	26.1687	2.0902
P1-P1	35.97	48.09	42.4856	2.4882	29.14	40.79	34.9152	2.2866
P2-P2	39.88	55.66	47.4243	2.6890	33.73	46.50	40.4085	2.4797
M1-M1	44.73	59.54	52.4746	2.9738	41.15	51.63	45.9211	2.3062
M2-M2	37.75	65.46	57.4504	3.9712	43.76	56.00	51.2656	2.6766
Length								
1-C	5.08	12.64	8.6631	1.6174	3.22	8.76	5.3509	1.0844
1-P1	12.72	18.96	15.3881	1.7186	8.00	14.66	11.0322	1.6232
1-P2	17.11	25.92	21.6362	2.0374	11.84	21.05	16.9144	1.9824
1-M1	22.80	31.12	27.3957	2.1606	18.00	27.76	23.6180	2.1047
1-M2	30.30	43.86	37.5502	2.7184	25.60	39.81	33.6000	2.9435

SD: Standard deviation, C-C: Inter canine distance, P1-P1: Inter first premolar distance, P2-P2: Inter second premolar distance, M1-M1: Inter first molar distance, M2-M2: Inter second molar distance, 1-C: Canine vertical distance, 1-P1: First premolar vertical distance, 1-P2: Second premolar vertical distance, 1-M1: First molar vertical distance, 1-M2: Second molar vertical distance.

Table (2) demonstrated the comparison of the mean dimension data of upper and lower dental arch between male and female groups. It was found that the male group generally exhibits larger values of dental arch dimensions than female group.

Tables (3) and (4) contained, respectively, the intra- and inter-arch correlation of upper and lower dental arches dimensions for total group and for female and male groups also. These Tables showed highly significant intra- and inter-arch correlations. Table (5) explained the percentage

of some of these dimensions to each others. These included the upper and lower C-C and M1-M1 distances and the upper and lower 1-C and 1-M1 distances.

The results of facial measurements were also recorded. Table (6) contained the mean and standard deviation of these measurements, while Table (7) explained the difference between the female and male groups. It is clear that the male group exhibited larger facial dimensions than female group.

Table (2): Comparison of dental arch dimensions between female and male groups

Width						
Upper						
Variables	Female		Male		t-value	Significance
	Mean	± SD	Mean	± SD		
C-C	34.6021	2.4934	35.1379	2.3549	0.779	Not Significant
P1-P1	41.9313	2.4876	43.2721	2.5647	1.892	Not Significant
P2-P2	46.6379	2.6214	48.3308	2.6730	2.284	Significant
M1-M1	51.4217	3.0622	53.2042	2.6836	2.044	Not Significant
M2-M2	55.7413	4.4264	59.2667	2.5030	3.664	Significant
Lower						
C-C	26.3188	1.9567	26.1492	2.3775	-0.277	Not Significant
P1-P1	34.7779	2.0381	35.2746	2.6743	0.681	Not Significant
P2-P2	40.0988	2.1522	40.8867	2.8851	0.947	Not Significant
M1-M1	45.2842	2.0972	46.4546	2.4925	1.727	Not Significant
M2-M2	50.6013	2.1516	51.7367	3.1584	1.426	Not Significant
Length						
Upper						
1-C	8.3983	1.3719	8.9450	1.9237	1.249	Not Significant
1-P1	15.2204	1.6861	15.7471	1.8221	1.165	Not Significant
1-P2	21.3796	1.8672	22.1937	2.1011	1.434	Not Significant
1-M1	27.3008	2.1749	27.8583	2.0822	0.809	Not Significant
1-M2	37.2550	2.7823	38.1746	2.5132	1.110	Not Significant
Lower						
1-C	5.2754	1.1183	5.4867	1.0669	0.743	Not Significant
1-P1	11.0004	1.4940	11.3821	1.6439	1.020	Not Significant
1-P2	16.8637	1.7879	17.3362	2.1232	0.884	Not Significant
1-M1	23.6875	1.6658	24.0179	1.8352	0.592	Not Significant
1-M2	33.6613	2.5238	34.5688	2.5394	1.433	Not Significant

SD: Standard deviation, C-C: Inter canine distance, P1-P1: Inter first premolar distance, P2-P2: Inter second premolar distance, M1-M1: Inter first molar distance, M2-M2: Inter second molar distance, 1-C: Canine vertical distance, 1-P1: First premolar vertical distance, 1-P2: Second premolar vertical distance, 1-M1: First molar vertical distance, 1-M2: Second molar vertical distance.

Table (3): Intraarch correlation of dental arch dimensions

		Width							
Variables	Sex	Upper				Lower			
		C-C	P1-P1	P2-P2	M1-M1	C-C	P1-P1	P2-P2	M1-M1
P1-P1	M	0.821**				0.826**			
	F	0.786**				0.641**			
	T	0.790**				0.752**			
P2-P2	M	0.783**	0.820**			0.715**	0.899*		
	F	0.807**	0.874**			0.597**	0.881**		
	T	0.768**	0.851**			0.659**	0.892**		
M1-M1	M	0.593**	0.593**	0.679**		0.280	0.408*	0.566**	
	F	0.733**	0.776**	0.853**		0.402	0.594**	0.614**	
	T	0.629**	0.696**	0.779**		0.300*	0.473**	0.588**	
M2-M2	M	0.466**	0.339	0.435*	0.530**	0.290	0.362*	0.463**	0.667**
	F	0.095	0.028	0.216	0.313	0.536**	0.663**	0.588**	0.708**
	T	0.241	0.228	0.379**	0.475**	0.347*	0.457**	0.511**	0.696**
		Length							
		1-C	1-P1	1-P2	1-M1	1-C	1-P1	1-P2	1-M1
1-P1	M	0.705**				0.431*			
	F	0.732**				0.617**			
	T	0.713				0.506**			
1-P2	M	0.498**	0.403*			0.561**	0.372*		
	F	0.813**	0.795**			0.422*	0.736**		
	T	0.612**	0.561**			0.501**	0.504**		
1-M1	M	0.491**	0.491**	0.889**		0.590**	0.534**	0.558**	
	F	0.651**	0.651**	0.679**		0.371	0.521**	0.527**	
	T	0.546**	0.573**	0.796**		0.497**	0.526**	0.545**	
1-M2	M	0.409**	0.440*	0.849**	0.922**	0.411*	0.649**	0.292	0.642**
	F	0.572**	0.567**	0.457*	0.773**	0.572**	0.672**	0.707**	0.684**
	T	0.510**	0.500**	0.687**	0.850**	0.46**	0.655**	0.431**	0.654**

*Significant at 0.05 level, **Highly significant at 0.01 level, M: Male, F: Female, T: Total, C-C: Inter canine distance, P1-P1: Inter first premolar distance, P2-P2: Inter second premolar distance, M1-M1: Inter first molar distance, M2-M2: Inter second molar distance, 1-C: Canine vertical distance, 1-P1: First premolar vertical distance, 1-P2: Second premolar vertical distance, 1-M1: First molar vertical distance, 1-M2: Second molar vertical distance.

Table (4): Interarch correlation of dental arch dimensions

		Variables				
Lower	Sex	Upper				
		Width				
		C-C	P1-P1	P2-P2	M1-M1	M2-M2
C-C	M	0.534**	0.383*	0.491**	0.512**	0.294
	F	0.210	0.305	0.307	0.165	0.089
	T	0.394**	0.329*	0.382**	0.314*	0.143
P1-P1	M	0.597**	0.510**	0.515**	0.522**	0.488**
	F	0.245	0.560**	0.448*	0.268	-0.103
	T	0.451**	0.526**	0.482**	0.403**	0.196
P2-P2	M	0.558**	0.582**	0.620*	0.548**	0.393*
	F	0.210	0.473**	0.434	0.231	-0.037
	T	0.414**	0.544**	0.552**	0.420**	0.206
M1-M1	M	0.485**	0.562**	0.580**	0.526**	0.344
	F	0.213	0.544**	0.516	0.372	0.108
	T	0.360**	0.575**	0.582**	0.496**	0.290*
M2-M2	M	0.213	0.218	0.314	0.400*	0.508**
	F	0.423*	0.625**	0.643**	0.564**	0.309
	T	0.238*	0.392**	0.463**	0.491**	0.439**
		Length				
		1-C	1-P1	1-P2	1-M1	1-M2
1-C	M	0.711**	0.461*	0.567**	0.537**	0.510**
	F	0.453*	0.311*	0.312*	0.203	0.272
	T	0.605**	0.397**	0.462**	0.387**	0.404**
1-P1	M	0.551**	0.798**	0.432*	0.518**	0.429*
	F	0.730**	0.622**	0.617**	0.365	0.402
	T	0.607**	0.726**	0.499**	0.455**	0.416**
1-P2	M	0.461*	0.199	0.524**	0.459*	0.394*
	F	0.599**	0.440**	0.389	0.190	0.316
	T	0.505**	0.292*	0.475**	0.352**	0.360**
1-M1	M	0.523**	0.459*	0.610**	0.671**	0.631**
	F	0.405*	0.532**	0.431*	0.605**	0.513*
	T	0.477**	0.474**	0.543**	0.636**	0.571**
1-M2	M	0.364*	0.497**	0.467**	0.488**	0.385*
	F	0.574**	0.536**	0.472*	0.433	0.355
	T	0.423**	0.505**	0.463**	0.462**	0.366**

*Significant at 0.05 level, **Highly significant at 0.01 level, M: Male, F: Female, T: Total, C-C: Inter canine distance, P1-P1: Inter first premolar distance, P2-P2: Inter second premolar distance, M1-M1: Inter first molar distance, M2-M2: Inter second molar distance, 1-C: Canine vertical distance, 1-P1: First premolar vertical distance, 1-P2: Second premolar vertical distance, 1-M1: First molar vertical distance, 1-M2: Second molar vertical distance.

Table (5): Percentage of some of dental arch dimensions to each other

Width		Length	
Variables	Percentage	Variables	Percentage
<u>Upper C-C</u> Upper M1-M1	65.99 %	<u>Upper 1-C</u> Upper 1-M1	31.62%
<u>Lower C-C</u> Upper C-C	75.56 %	<u>Lower 1-C</u> Upper 1-C	22.65%
<u>Lower C-C</u> Lower M1-M1	56.98 %	<u>Lower 1-C</u> Lower 1-M1	61.76%
<u>Lower M1-M1</u> Upper M1-M1	87.51 %	<u>Lower 1-M1</u> Upper 1-M1	86.21%

C-C: Inter canine distance M1-M1: Inter first molar distance, M2-M2: Inter second molar distance, 1-C: Canine vertical distance, 1-M1: First molar vertical distance.

Table (6): Descriptive statistics of facial measurements

Variables	Minimum	Maximum	Mean	± SD
IAW	18.36	42.24	34.6661	3.7732
MW	31.47	55.04	46.5219	4.2840
IPD	40.31	63.05	55.6930	4.0648
BZW	109.63	143.30	129.0591	6.1772

SD: Standard deviation, IAW: Interalar width, MW: Mouth width, IPD: Interpupillary distance, BZW: Bizygomatic width.

Table (7): Comparison of facial measurements between female and male groups

Variables	Female		Male		t-value	Significance
	Mean	± SD	Mean	± SD		
IAW	33.3679	2.1486	35.6442	4.8560	2.036	Not Significant
MW	45.6892	3.1168	47.2512	5.4884	1.195	Not Significant
IPD	54.2117	3.0051	56.8625	4.8981	2.409	Significant
BZW	126.3221	4.0602	131.3008	7.1880	3.530	Significant

SD: Standard deviation, IAW: Interalar width, MW: Mouth width, IPD: Interpupillary distance, BZW: Bizygomatic width.

Table (8) illustrated the significant correlation between the recorded facial measurements, while Table (9) showed the correlation of these measurements to the upper and lower C-C and the upper and lower M1-M1 distances. It appeared that the upper C-C distance was significantly correlated to the MW and the upper M1-M1 distance was significantly correlated to the BZW. Therefore, the percentage of these significantly correlated variables was taken (Table 10).

DISCUSSION

Generally in this study, it was obvious that the mean values of all the measurements taken for the dimensions of the maxillary dental arch (width and length) were larger than the mandibular arch. This confirmed the accepted view that the maxillary dental arch overlaps the mandibular arch.^(7, 8) On other hand, it was found that the dimensions of maxillary and mandibular dental arches (width and length) in male group were generally larger than female

group. This result came in accordance with the result of other previous studies.⁽⁹⁻¹¹⁾ The sex difference in the dental arch dimensions could be related to the fact that the thickness of the crest of the bony ridge varies in both sexes, which was smoother

and smaller in female compared to that of male.⁽¹²⁾ Also the average weakness of the musculature in female plays an important role in the facial breadth measurements, width and length of the maxillary dental arch.⁽¹³⁾

Table (8): Correlation of facial measurements to each other

Variables	Sex	IAW	MW	IPD
MW	M	0.605**		
	F	0.206		
	T	0.546**		
IPD	M	0.688**	0.643**	
	F	0.565**	0.014	
	T	0.692**	0.502**	
BZW	M	0.689**	0.556**	0.717**
	F	0.339	0.063	0.179
	T	0.665**	0.638**	0.638**

**Highly significant at 0.01 level, M: Male, F: Female, T: Total sample, IAW: Interalar width, MW: Mouth width, IPD: Interpupillary distance, BZW: Bizygomatic width.

Table (9): Correlation of facial measurements to some dimensions of dental arch

Variables	Sex	IAW	MW	IPD	BZW
Upper C-C	M	0.172	-0.275	0.347	0.287
	F	0.431	0.420*	0.022	-0.71
	T	0.223	0.312*	0.201	0.153
Upper M1-M1	M	-0.010	0.145	0.167	0.328
	F	0.398	0.213	0.077	0.279
	T	0.195	0.208	0.220	0.385**
Lower C-C	M	-0.273	-0.131	-0.047	-0.080
	F	0.427*	0.404	0.205	0.382
	T	-0.108	0.019	0.010	0.025
Lower M1-M1	M	0.000	-0.043	0.024	-0.024
	F	0.063	0.100	0.023	0.116
	T	0.91	0.045	0.103	0.115

*Significant at 0.05 level, **Highly significant at 0.01 level, C-C: Intercanine distance, M1-M1: Inter first molar distance, IAW: Interalar width, MW: Mouth width, IPD: Interpupillary distance, BZW: Bizygomatic width.

Table (10): Percentage of facial measurements to some dimensions of dental arch

Variables	Percentage
<u>Upper C-C</u> MW	74.43 %
<u>Upper M1-M1</u> BZW	40.65 %

C-C: Intercanine distance, M1-M1: Inter first molar distance, MW: Mouth width, BZW: Bizygomatic width.

Generally there were significant intra- and inter-arch correlations of the upper and lower dental arch dimensions. Therefore, the calculations of the percentage of the dental arch dimensions at the upper and lower canines (which represents a part of the anterior segment of the dental arch) and the dimensions of arch at the upper and lower first molar (which represents a part of posterior segment of the dental arch) will be as a guide for the process of the ideal arrangement of the teeth of the artificial dental prosthesis.

Regarding the result of facial measurements, it was found that the result of these measurements was the same as the result of the dimensions of the dental arch in that the male group had also larger records than their corresponding records in female group. This result was in agreement with the result of other studies.⁽¹⁴⁻¹⁶⁾ This might simply reflect the greater overall breadth of the male skull in any given ethnic group.⁽⁵⁾ On the other hand, it was obvious that the mean width of the IAW was equal to C-C distance. This was in agreement with Mack⁽¹⁷⁾ and Lee⁽¹⁸⁾ but disagreed with Ali and Abdul-Rahim⁽⁶⁾ and Puri *et al.*⁽¹⁹⁾ as they found that there was a significant difference between them.

Finally, the result indicated that the facial measurements were significantly correlated to each other; a result which confirmed the result of previous studies.^(20, 21) It was also found that some of these facial measurements were significantly correlated to some dimensions of the upper dental arch. The correlation of lower dental arch with facial parameters were less than those in upper arch. This was possibly because the maxillary arch is anatomically correlated to the nose, orbit and zygoma than the mandibular dental arch.⁽²²⁾

The significant correlation between the upper C-C distance and the MW, and between the upper M1-M1 distance and the BZW and the recorded percentage between these measurements was equal to 74.43% (upper C-C distance to MW) and 40.65% (upper M1-M1 distance to the BZW). These percentages are of practical importance to the prosthodontists so that they can determine the accurate C-C and M-M distance of the dental prosthesis before observing the study models of the pati-

ents. This can easily be done by measuring the MW and the BZW of the patients and then they can accurately determine the dimensions of the artificial dental arch by using the previously mentioned percentage.

CONCLUSIONS

Knowledge of the standards for the dental arch dimensions in human population is of great value to the clinicians in different fields of dentistry as prosthodontics, orthodontics and orthognathic surgery.

The maxillary dental arch exhibited larger values of dental arch dimensions than the mandibular dental arch. Also, the male group generally exhibited larger values of dental arch dimensions and facial measurements than the female group.

There was a significant correlation of some dimensions of upper dental arch to some of facial measurements and the percentage of the upper C-C distance to MW was equal to 74.43% and the percentage of the upper M1-M1 distance to the BZW was equal to 40.65%.

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