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Comparison of the arch forms and dimensions in various malocclusions of the Turkish population

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ABSTRACT

Objectives: The aim of this study is to determine the distribution of morphological differences in the clinical mandibular arch forms seen in Angle Class I, II and III malocclusions in Turkish population and to examine the effect of gender on arch dimension parameters. Material and methods: This study has been conducted on pretreatment mandibular study models of 600 individuals (362 girls, 238 boys) aged between 14 and 19. On the photocopies derived from these models, 4 linear and 2 proportional measurements have been made. The samples have been evaluated as square, ovoid and tapered (OrthoForm-3M Unitek) arch form templates. Results: The most frequent arch form encountered among all the groups was the tapered one (62.5%) followed by the ovoid (27.3%) and the square one (10.2%). Gender difference influences on morphological structure was apparent. Generally, compared with girls, arch width and depth were found to be more in boys. Conclusions: The most frequent arch form seen in Angle malocclusion groups was the tapered one, followed by the less frequent ovoid and square ones.

Keywords: Arch Form; Arch Dimension; Sex Differences

1. INTRODUCTION

While a parameter curve displays a perfect conformity with the arches, in 40% - 50% of the patients this accordance shows a decrease [1]. It can be accepted that in at least half of the patients the preformed arch wires don't seem to be functional [2]. Because of these reasons, the routinely used superelastic preformed arch wires have to be in various forms with individual malocclusion adaptations.

Most of the studies conducted on arch form are focused on finding a single shape in perfect conformity for

the dental arch of a specific sample [3]. Despite individual differences, when the ethnical variations are taken into consideration; the application of a single ideal arch form for every individual could effect the post treatment functional, esthetic and stable arch form outcomes [4].

In 1932 Chuck [5] classified the arch forms as tapered, ovoid and square for the first time. These arch forms can also be expressed as narrow, normal and wide. Especially in determining the arch wire forms utilized at the initial phase of the treatment, he advocates that making a choice between these three forms would be better than using a single arch form [5]. For this reason, in leveling and arrangement phases, the most convenient arch form type according to the ethnical origin and malocclusion of the patients should be chosen from the preformed superelastic arch wires [4,6].

There are some studies aimed at determining the arch forms specific to various ethnical groups [4,6-8]. In a study where Kook, Y. A. *et al.* [4] determined the ethnical differences between Korean and North Caucasian groups, arch forms passing through clinical brackets which is appraised as a valuable approach in modern orthodontic technics were used.

Although there have been studies one on the evaluation of arch forms in various groups, no such research has been performed on the Turkish population; this fact has urged us to carry out this study. The aim of this study is to determine the differences of clinical mandibular arch forms in Angle Class I, II, and III malocclusions in the Turkish population by identifying its morphological variations and to evaluate gender differences with respect to arch dimension parameters.

2. MATERIAL AND METHODS

This study consisted of 600 subjects' (362 female, 238 male) pretreatment mandibular dental casts between the ages of 14 and 19 years, among whom 200 were Angle Class I, 200 were Class II and 200 were Class III (**Table 1**).

The following inclusion criterias were used before assessing the patients:

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Table 1. Distribution of sex, age and arch forms accordig to the Angle classifications.

Samples	Number	Boys	Girls	Mean Age (years)	Standard Deviation
Tapered Arch Form					
Class I	135	49	86	15.63	1.72
Class II	130	52	78	15.36	1.67
Class III	110	42	68	16.17	1.79
Ovoid Arch Form					
Class I	50	14	36	15.16	1.72
Class II	57	28	29	15.56	1.69
Class III	57	21	36	16.35	1.77
Square Arch Form					
Class I	15	8	7	15.47	1.36
Class II	13	3	10	16.08	1.60
Class III	33	21	12	15.61	1.64
Total	**600**	**238**	**362**	**15.63**	**1.71**

1) Angle Class I, II, and III malocclusions.
2) Permanent dentition without atrision or fractures in the incisal edges or cusp tips in permanent dentition.
3) No restorations extending to the approximal faces, cusp tips or incisal edges.
4) Arch discrepancies (crowding or diastemas) less than 3 mm.

The photocopies (Rex-Rotary DSm635 Aficio™, 2005, Japan) of the occlusal surfaces of the mandibular models and the arrangement of the datas according to the XY coordinate was done as Nojima, K. *et al.* [6] suggested. On the photocopied images the most facial portions of 13 proximal contact areas were marked to determine the clinical bracket points (**Figure 1**).
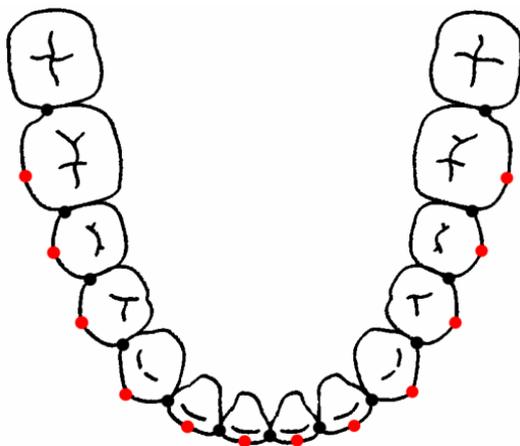

Figure 1. Black dots; points digitized on occlusal photocopy which represent the most facial portions of 13 proximal contact areas, red dots; clinical bracket points that place in the middle of the proximal points of each teeth.

Figure 2 shows the arch shape differences between the three arch forms; tapered, ovoid and square (Ortho-form, 3M Unitek, Calif) when superimposed as described by R. P. McLaughlin, J. C. Bennett and H. J. Trevisi [9]. One of the 3 arch forms that best fits with the sample's arch that consists 8 teeth's clinical bracket points between 1st premolars were selected.

The following 4 linear and 2 proportional measurements of arch dimensions were taken (**Figure 3**):

- Inter-canine width: the distance between the canine clinical bracket points.
- Inter-molar width: the distance between the first molar clinical bracket points.
- Canine depth: the shortest distance from a line connecting the canine clinical bracket points to the origin between the central incisors.
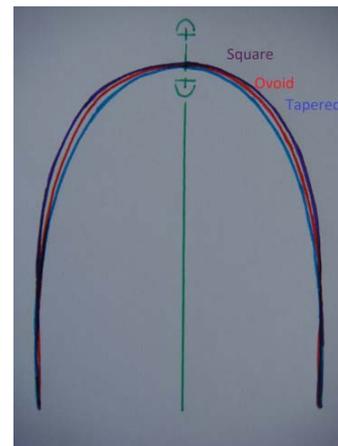

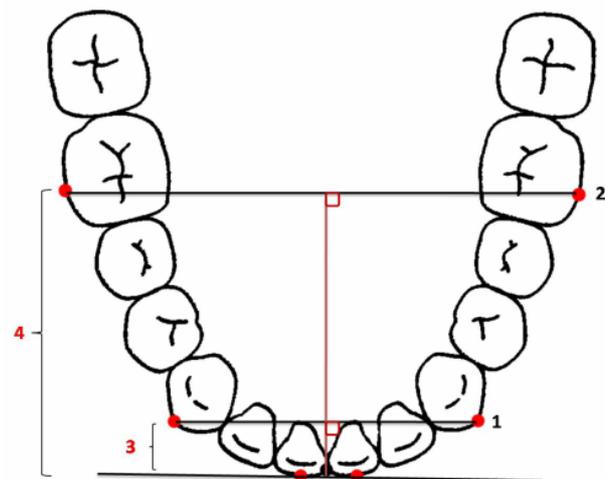**Figure 2.** The superimposition of mandibular arch forms.

Figure 3. Determination of the clinical bracket points and 4 linear and 2 proportional measurements of arch dimensions. 1) intercanine width; 2) intermolar width; 3) intercanine depth; 4) intermolar depth; 5) canine W/D ratio; 6) molar W/D ratio.

- Molar depth: the shortest distance from a line connecting the first molar clinical bracket points to the origin between the central incisors.
- Canine W/D ratio: the ratio of the inter-canine width and the canine depth.
- Molar W/D ratio: the ratio of the inter-molar width and the molar depth.

3. STATISTICAL ANALYSIS

The dental data from Angle classification and arch form groups were statistically assessed by using SPSS 15.00 and MedCalc v.11.2 statistical software programs in Ege University, Faculty of Medicine, Department of Biostatistics and Medical Informatics. All analyses were tested at the significance level of 0.05. Dahlberg's [10] error of method formula was used to calculate the error of measured data. According to this method, 50 mandibular dental cast photocopies were randomly selected and all measurements were repeated on these models. The differences between the two measurements were determined and used in the following formula to find out the standard error of the method with lower and upper borders (**Table 2**).

$$Sm = \sqrt{\frac{\sum d^2}{nx2}} \quad \text{(Error of the Standard Method)}$$

According to the formula, the error of the method is closer to 0 (zero) means the measurement accuracy, as it gets closer to 1 (one) the incidence of the method error rises. Our findings were between 0.01 and 0.17 which indicates accuracy of the method.

As the arch form classification shows up ordered data, Weighted Kappa statistics were used to evaluate the intra-rater agreement. The effect of sex on arch form distribution were evaluated by using chi-square test. Arch dimension measurements in Angle classes and arch form classes were evaluated by using Oneway-ANOVA and Bonferroni Tests which is one of the Post Hoc tests. The effect of sex on arch dimension measurements were evaluated by using independent samples tests.

Table 2. The Dahlberg's Error of the Method, lower and upper limit values.

Measurements	Error of the Standard Method (Sm)	Lower Limit	Upper Limit
3-3 width	0.12	0.09	0.17
6-6 width	0.12	0.98	0.76
3-3 depth	0.16	0.12	0.23
6-6 depth	0.14	0.11	0.20
3-3 W/D	0.17	0.13	0.24
6-6 W/D	0.01	0.01	0.02

4. RESULTS

Mandibular arch forms of 600 patients were evaluated according to the Angle classification. In Angle Class I samples, the tapered arch form showed the highest frequency as 67.5% whereas ovoid and square arch forms were less frequent (**Figure 4**). The arch form distribution in Angle Class II malocclusion samples were 65% tapered, 28.5% ovoid, and 6.5% square arch forms. In Angle Class III samples, the tapered arch form showed the highest frequency as 55%, following ovoid (28.5%) and square (16.5%) arch forms. The arch form distribution between Angle Class I and II was statistically insignificant (p = 0.71). The difference within three classification was due to Angle Class III malocclusion.

Even though the arch form distribution in Angle Class III group was similar to the other two groups, the square arch form showed higher frequency among the groups. This result was statistically significant. After evaluation of the best fitted arch form for each dental cast, a second evaluation was done by the same author (SO) to define the intra-rater agreement and the Kappa value was 0.83 indicating "very good" agreement.

Evaluation of arch dimensions for Angle classifications are shown in **Table 3** with no difference in terms of inter-canine width (p = 0.59). Molar width in Class III was higher than Class I and II (p < 0.001 and p < 0.05,
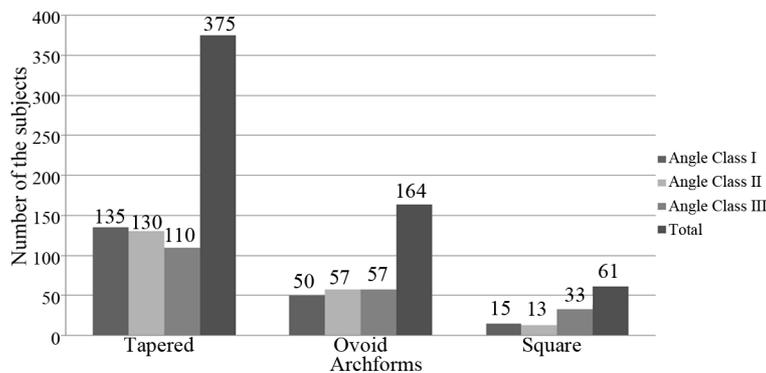

Figure 4. The distribution of tapered, ovoid and square arch forms according to the Angle classification.

respectively). Canine depth showed the least value in Class III assigning flatter anterior portion of the arch where as there was no statistically significant difference between Class I and III regarding canine depth. Molar depth measurements from highest to least were Class II, I and III which was also statistically significant. The canine and molar W/D ratios were increased in Class III as an expected outcome.

Table 4 shows the arch dimension measurements of the regrouped dental cast photocopies according to the square, ovoid and tapered arch forms. Mandibular arch forms showed increasing inter-canine width, inter-molar width, canine W/D ratio, and molar W/D ratio and decreasing canine depth, and molar depth as the mandibular arches changed in form from tapered to ovoid and ovoid to square.

The effect of sex on arch form distribution was evaluated by using chi-square test. Although there was no differences between the groups, square arch form was more frequent in boys. The effect of sex on arch dimension measurements were evaluated by using independent samples tests. Measurements concerning these p values are presented in **Table 5**. Inter-canine width and inter-molar width measurements were higher in boys than in girls (0.76 mm and 1.34 mm, respectively). Similar relationship occurred in arch depth measurements with ca-

nine depth being 0.22 mm ($p < 0.05$) and molar depth being 0.99 mm ($p < 0.001$) more in boys. The canine and molar W/D ratios were not effected by sex. Both values were less in boys which was not statistically significant.

5. DISCUSSION

In the present study the age distribution was limited with 14 - 19 in order to eliminate the variations in arch dimensions related with age. After examining the differences in arch width in relationship with age, Bishara *et al.* [11] stated that although they had observed a reduction in canine width between 13 - 26 and 26 - 45 in men and women, only the reduction detected in women between 26 - 45 was statistically important. Even though there is an increase in mandibular canine width until 13 years; this increase is found to be statistically important in boys until 8 and in girls until 13 years of age. After 13 years of age, the canine width shows a reduction in 25 and 45 years. In Bishara's study the inter-molar width didn't show a significant change between 13 - 26 and 26 - 45 years.

In most of the conventional studies, the tubercule tips and incisal edges are taken as landmarks in determining the arch form. In our study, the clinical bracket points which correspond to bracket slots were used as landmarks for the identification of the mandibular arch forms.

Table 3. Comparison of arch parameters by Angle classifications.

	1. Angle Class I		2. Angle Class II		3. Angle Class III		
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	*Significant differences between groups*
Intercanine width (mm)	27.89	1.69	28.05	1.88	27.89	1.86	NS
Intermolar width (mm)	48.00	2.52	48.16	2.48	48.88	2.87	2 - 3*; 1 - 3**
Canine depth (mm)	5.36	1.10	5.77	1.05	5.15	1.08	1 - 2***; 2 - 3***
Molar depth (mm)	26.79	2.09	27.32	2.24	26.21	2.15	1 - 2*; 2 - 3***; 1 - 3*
Canine W/D ratio	5.47	1.43	5.03	0.99	5.72	1.67	1 - 2**; 2 - 3***
Molar W/D ratio	1.80	0.17	1.77	0.17	1.88	0.19	2 - 3***; 1 - 3***

NS, Not Significant ($p > 0.05$); *$p < 0.05$; **$0.01 < p < 0.05$; ***$p < 0.001$.

Table 4. Comparison of arch parameters by Arch forms.

	1. Tapered Arch Form		2. Ovoid Arch Form		3. Square Arch Form		
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	*Significant differences between groups*
Intercanine width (mm)	27.52	1.68	28.58	1.87	28.84	1.71	1 - 2***; 1 - 3***
Intermolar width (mm)	47.26	2.30	49.67	2.04	51.47	1.96	1 - 2***;2 - 3***;1 - 3***
Canine depth (mm)	5.72	1.07	5.12	0.95	4.42	0.91	1 - 2***;2 - 3***;1 - 3***
Molar depth (mm)	27.17	2.13	26.48	2.03	25.11	2.20	1 - 2**;2 - 3***;1 - 3***
Canine W/D ratio	4.99	1.18	5.80	1.34	6.84	1.76	1 - 2***;2 - 3***;1 - 3***
Molar W/D ratio	1.75	0.14	1.89	0.14	2.07	0.19	1 - 2***;2 - 3***;1 - 3***

*$p < 0.05$; **$0.01 < p < 0.05$; ***$p < 0.001$.

Table 5. Arch parameters in boys and girls.

	N	Mean	SD	Min	Max	*p*
Intercanine width						***
Girls	362	27.64	1.74	22.50	33.00	
Boys	238	28.40	1.82	23.00	34.00	
Intermolar width						***
Girls	362	47.81	2.59	40.00	56.00	
Boys	238	49.15	2.55	43.00	56.00	
Canine depth						*
Girls	362	5.34	1.04	2.00	9.00	
Boys	238	5.56	1.19	2.00	9.00	
Molar depth						***
Girls	362	26.38	2.03	20.00	33.00	
Boys	238	27.37	2.33	22.00	34.00	
Canine W/D ratio						NS
Girls	362	5.42	1.41	3.22	14.50	
Boys	238	5.38	1.44	3.13	15.50	
Molar W/D ratio						NS
Girls	362	1.82	0.17	1.45	2.52	
Boys	238	1.81	0.19	1.39	2.55	

NS, Not Significant ($p > 0.05$); *,$p < 0.05$; ***, $p < 0.001$.

The aim in specification of the "bracket" arch form was to evaluate the final arch form which will be obtained by the use of fix orthodontic appliances in patients who have referred to our clinic due to orthodontic disorders. In recent studies this arch form which is thought to be more realistic is preferred in determining the individual arch form [4,6-9].

Arch form templates used in the evaluation of photocopies of mandibular models are the 3 type of (narrow, normal and wide) arch forms specified by Bennett, McLaughlin and Trevisi [9] and used by Chuck [5] for the first time in 1932. The transversal difference produced between the three arch forms by superimposition is specified as 6 mm [9].

According to our study, there was no significant difference with respect to arch form variance between Class I and Class II arches. Tapered arch form was seen in high frequency in both groups whereas the sequence of ovoid arch form was less. Similar results have been obtained in studies performed by Felton *et al.* [12].

In studies aiming at determination and difference of arch forms between races [4,6-8], square arch form is the most frequent one in Class III malocclusion individuals. However, in our study when Class I and II are compared, although the frequency of square arch form was more in Class III arches, the sequence of tapered arch form was higher.

Upon examination of the arch dimension differences between Angle classes, while our study didn't reveal a statistically significant difference between classes in terms of canine width; molar width in Class III arches were found to be 0.88 mm more with respect to Class I

and 0.72 mm more with respect to Class II. The molar width increase in Class III arches can be explained by lingual tipping of the anterior teeth in Class III development and flattening of the anterior area besides the lateral growth of the tongue due to the decrease of the molar depth [4,13]. The findings regarding a difference of 1 mm on average were statistically significant and also assumed to be clinically significant since arch form tends to return toward the original or even narrower pretreatment form after retention period. Therefore minimal treatment changes would be in great significance to prevent post treatment relapse tendency [3]. In the report published by Braun *et al.* [13] on arch dimension differences between Angle classifications, it is also similarly stated that; starting from the premolar area mandibular arches with Class III malocclusion are averagely 2.1 mm wider with respect to Class I mandibular arches. Basaran *et al.* [14] compared the dental arch widths in Class I, Class II div 1 and Class III groups and found no difference with regard to mandibular canine width in the three groups; which was similar with our results. When mandibular molar width was considered, while no difference could be detected between Class I and Class III, upon comparison of these groups with Class II div 1; statistically significant differences were observed.

In our study, while canine width was more in Class II arches with respect to Class I and III, Class III arches were less than Class I and Class II in terms of molar depth. Our results were similar with the results of Kook *et al.* [4] and Bayome *et al.* [7]. Accordingly, Class II canine width is more than the Class I samples. Braun *et al.* [15] stated that when compared with Class I arches,

Class II mandibular arches generally show decreased arch width and depth. At the same time, it was shown that the Class III mandibular arches have averagely 3.3 mm less depth with regard to Class I. In their comparison of Caucasian and Japanese mandibular arch forms Nojima *et al*. [6] found that the Class I arches are deeper for both of the ethnical groups with regard to Class II arches and this is not consistent with our results. In the same study it was concluded that Class III arches are the shallowest and widest of all.

Apart from this, it was shown that the Class II arches possess the least canine W/D ratio followed by Class I and Class III. Class III arches have the highest molar W/D ratio followed by Class I and Class II arches. In the study of Kook *et al.* [4] both the canine and the molar W/D ratio is the least in Class II arches followed by Class I and Class III. Similar results have been found in studies reported by Nojima *et al.* [6] and Gafni *et al.* [8].

By examining the arch dimensions with regard to gender, it was found that the arch dimension is remarkably higher in boys than girls in the permanent dentition. These findings are in accordance with Bishara [13]. In a study where especially arch width, depth and chord measurements were evaluated, Cassidy *et al.* [16] found that these values are 3% - 5% higher in boys. In Carter and McNamara's study [17] it was stated that the arch depth decreases in canine, first and second premolar and first molar teeth area in both genders. In Ward *et al.*'s [18] study the results showed no differences in boys and girls.

In most of the studies, although the values are less in girls, there is a relationship with the gender and arch dimension of the samples. In the study done by Raberin *et al.* [19] there were significant differences related with gender only in the transversal dimensions. In present study even though there are significant differences with respect to gender and canine/molar width, both of the measurements are found to be higher in boys. Although boys possess a wider arch form than girls, there is an overall agreement that there is no gender variance with respect to arch form [20,21]. As it can be derived from our results, no statistically significant variances were found between gender and arch form.

6. CONCLUSIONS

Due to the lack of studies aimed at dental arch form variances in Turkey, in our study:

1) It was determined that the most frequently seen arch form in the Angle malocclusion groups was the tapered, the least frequent one was the ovoid and the square one, respectively.

2) Arch widths and depths were found to be more in boys when compared with girls.

3) No significant differences were found between gender and arch form variances.

4) In the evaluation of arch dimension measurements with regard to Angle malocclusion groups, Angle Class III had the highest values in molar width and the least values in canine and molar depth measurements.

With this study, it is foreseen that the arch form should be determined in relation with each patients' pretreatment mandibular dental model and especially in relation with each patients' ethnic group in order to achieve an esthetic, functional and stable arch form outcome.

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