

MANDIBULAR ARCH FORM ANALYSES: A COMPARISON BETWEEN RESULTS OF TWO DIFFERENT METHODS

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ABSTRACT

This study was conducted to determine the morphology of mandibular dental arch forms. Two different methods were used for this purpose and compared to find out the frequency distribution. It was conducted on 100 patients visiting Lahore Medical and Dental College, Lahore. Dental casts were photocopied and investigated to find out the square, tapering and ovoid arch forms. A mathematical model of arch form determination advocated by Noroozi and superimposition of orthoform templates were the two methods used. A comparison of frequency distribution for the results of two methods was carried out by applying "Chi square" test. Cross tabulation was done to study the congruence of the two methods on various arch forms. Frequency distribution of ovoid, square and tapering arch forms was 74%, 14% and 12% respectively by Noroozi's mathematical model and 56%, 7% and 37% respectively by the orthoform templates.

There was a noteworthy difference in frequency distribution of arch forms according to the two methods. The p-value ($p < 0.001$) was statistically significant. However both methods showed ovoid arch form as the most prevalent in the sample.

Key Words: Arch form analysis.

INTRODUCTION

The ultimate goal of any dental treatment is to prevent further damage and future problems, in the existing situation rather than mere correction or restoration. There is continuous effort in the profession for minimizing the iatrogenic trauma and prevention of complications related to treatment. The intention is to restore within the guidelines provided by nature. One such guideline is the shape of maxillary and mandibular arches. The dental arch is a composite structure of natural teeth and alveolar bone. It is described in the glossary of prosthodontic terms as "the geometric shape of the dental arch when viewed from the horizontal plane".¹ A dental arch describes the position and relationship of the teeth to one another in all three dimensions. Its shape is considered to result from the influence of the surrounding soft tissues, the basic skeletal morphology, and other additional environmental effects.²

Over the years the human dental arch form is recognized to be variable in shape and size. It is described by many authors in geometric forms (ellipse, parabolic curve and hyperbolic) and mathematical functions.³⁻⁵ Classic studies have described the arch forms clinically as square, round, oval, tapering etc.⁶ but the conventional methods of determining arch form are subjective and depend on personal visual examination. These methods lack mathematical evidence and may result in dissimilar comprehension between two observers.^{2,7,8} Conversely, the mathematical methods of evaluation involve measurement of distances between specific reference points and use of various algebraic functions to analyze the arch form and have described 4 to 5 different shapes.⁹ These quantitative methods result in enormous data requiring intricate adjustments with sophisticated apparatus.¹⁰ Some authors argue that anatomical structures could not be reduced to the mathematical precision of geometrical terms.¹¹

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In Prosthodontics, information on arch form is of significant value in construction of any artificial dental prosthesis. It provides indispensable information about anterior teeth selection¹² and arrangement.¹³ This holds true not only for the fabrication of conventional complete dentures where the arrangement of artificial teeth should follow the arch form of the natural predecessors as closely as possible,¹⁴ but also for the conventional and implant retained fixed dental prostheses.¹⁵ While restoring missing anterior teeth with fixed dental prosthesis the arch form along with the above mentioned guidance also dictates the number of abutments used. This is because tapering arches require secondary/additional abutments to counteract the torsional forces created by the increased distance of pontics from the abutments.¹⁶ Whereas, the square and tapering arches may only need the primary abutments.¹⁶ Similarly, when designing a prosthesis on implants, the shape of the arch form dictates not only the number of implants (more for tapering arches) but also the type of prosthesis as cantilever type of prosthesis is not recommended for tapering arches.^{15,17}

In Orthodontics, it is important that the arch form is observed before the treatment is started as the post treatment occlusal stability depends on preservation of the original arch form.^{18,19} It provides a reliable guideline about the position into which the teeth can be moved.²⁰ Orthodontic relapse occurs when teeth are placed outside the soft tissue envelope.²¹ Familiarity with the existing arch form is also important when selecting the preformed arch wires.¹⁸

Considering the limitations of the subjective and mathematical methods, this study aimed to find the shapes of mandibular arch forms with two dissimilar methods and to compare their results. This type of comparison was previously done for the maxillary arches but the authors could not find any similar study on mandibular arches.²² Two methods were used for this analysis, first method as proposed by Noroozi⁴, is a mathematical method, whereas the second uses orthoform templates by 3M Unitek which employs superimposition of the Diagnostic OrthoForm™ Templates on cast photocopies.²³

METHODOLOGY

This cross sectional study was conducted from May 2010 to December 2010 at Lahore Medical and Dental College, Lahore. One hundred subjects were selected with a convenient sampling technique; these included fifty males and fifty females. Consent was

taken from study participants, before proceeding with the study.

The age range of the subjects was 16-30 years. They all had normal healthy dentition, well aligned arches with all incisors, canines, first and second premolars and molars present. Individuals with periodontal disease, artificial restorations on anterior teeth, history of orthodontic treatment, malformed or malposed teeth, congenital and/or acquired maxillary defects, orthognathic/reconstructive surgical procedures were excluded.

The arch forms were determined on one hundred mandibular casts by using the two methods. The resultant information on square, tapering and ovoid arch forms was then compared to evaluate the difference between the results. Cross tabulation was done to observe congruence of both methods on three arch forms.

The first method employed was the mathematical formula of arch width and depth suggested by Noroozi⁴ ($Wc/Wm \times Dc/Dm$), this formula was employed to calculate the arch form. A standard vernier caliper (0-150mm by Jing Gong) was used to measure the arch width bilaterally at two reference points. Arch depth was measured on cast photocopies of 1x1 magnifications.^{24,25} All readings were taken three times at different occasions by the same observer, and in case of a discrepancy a mean value was calculated and noted. The formula was then applied to find a numerical value and arch form was determined as suggested by Noroozi.⁴ The second method employed the Diagnostic OrthoForm™ templates marketed by 3M Unitek according to the manufacturer's instructions. The arch forms were then determined by superimposing the templates on each cast photocopy.²³

SPSS program version 17 was used for statistical analysis of the collected data. Distribution of the arch forms established by the two methods was determined. In order to observe congruence between the results of the two methods, cross tabulation was done. Chi-square test of significance was applied to evaluate the difference in the results of two methods and p value of ≤ 0.05 was considered as the cut off point for statistical significance.

RESULTS

Arch form distribution according to Noroozi's mathematical formula and Diagnostic OrthoForm™ tem-

plates are presented in table 1 and table 2 respectively. The results revealed that the ovoid arch form was the most frequent. However, according to the mathematical formula it was 74% and according to the Diagnostic OrthoForm™ templates it was only 56%. The second most prevalent arch form was square (14%) according to the Noroozi's formula and tapering (37%) according to the Diagnostic OrthoForm™ templates. To find out the statistical difference between the results of two methods "Chi square" test was used. The calculated p-value ≤ 0.001 is statistically significant. Congruence of both methods was established by cross-tabulation. Interestingly, these methods have 82.1% agreement on ovoid, 21.6% on tapering and 71.4% on square arch forms. These results are shown in Table 3.

DISCUSSION

The literature describes many shapes of the arch forms. This study utilized the widely accepted practi-

TABLE 1: DISTRIBUTION OF ARCH FORMS BY NOROOZI'S MATHEMATICAL FORMULA

		Frequency	Percent
Arch form	Ovoid	74	74
	Square	14	14
	Tapering	12	12
	Total	100	100.0

TABLE 2: DISTRIBUTION OF ARCH FORMS USING DIAGNOSTIC ORTHOFORM™ TEMPLATES

		Frequency	Percent
Arch form	Ovoid	56	56
	Square	7	7
	Tapering	37	37
	Total	100	100.0

TABEL 3: CROSS TABULATION; NOROOZI AND DIAGNOSTIC ORTHOFORM™ TEMPLATES

			Diagnostic Orthoform (DO)			
			Ovoid	Tapering	Squarish	Total
Noroozi	Ovoid	Count	46	26	2	74
		% within DO	82.1%	70.3%	28.6%	74.0%
	Tapering	Count	4	8	0	12
		% within DO	7.1%	21.6%	0.0%	12.0%
	Squarish	Count	6	3	5	14
		% within DO	10.7%	8.1%	71.4%	14.0%
Total	Count		56	37	7	100
	% within DO		100.0%	100.0%	100.0%	100.0%

cal classification of ovoid, tapering and square arch form. Various methods have been proposed and used in this regard. These range from simple subjective visual examination to detailed and complex mathematical calculations. However, none of these proposed methods is universally accepted. This study was designed in a pursuit to identify a simpler and consistent method of determining arch form by comparing the results of two dissimilar methods. One selected method was based on mathematical calculation proposed by Noroozi and the second method was based on morphological evaluation by superimposing Diagnostic OrthoForm™ templates of MBT appliance system.

Mandibular arch has a different morphological behavior as compared to maxillary arch.²⁶ For the same reason this study was designed to compare the mandibular arches forms only. The arch forms and frequency distribution of the two methods were compared; the calculated p-value ≤ 0.001 is statistically significant. Both methods revealed that the ovoid arch form is most common (74% according to the mathematical method and 56% according to orthoform templates). However, second most arch form was tapering (37%), according to the orthoform templates and square (14%), according to mathematical formula. The difference in the results of two methods is considerable and significant. This difference also suggests that one or both of these methods are not giving the actual arch forms and hence have questionable validity and reliability.

The authors could not find any other study in the literature comparing results of two different methods in mandibular dental arches. However, there was one study with this comparison on the maxillary arches by the same authors.²²

Many studies have used the Orthoform templates to determine the mandibular arch forms.^{20,27-29} A re-

cent study conducted in Peshawar (Pakistan) on the mandibular arch reported tapering arch form (49.2%) as the most prevalent. It was followed by ovoid (29.2%) and square (21.2%).²⁰ This is in contrast to the results generated by the Orthoform templates in the present study, according to which ovoid (56%) is the most prevalent arch form, followed by tapering (37%). It might be due to ethnic differences in arch forms of selected samples; an aspect which was not reported in any of these studies. Multiple studies have already reported differences in arch forms of subjects from various ethnic backgrounds.^{27,30} Similar studies may be conducted in Pakistan to explore these differences.

A study comparing mandibular arches Hispanic and Caucasian sample found that the square arch form was most prevalent in Hispanic population (44%) followed by ovoid and tapering (28% each). Tapering arch form (44%) was more common in Caucasians followed by ovoid (38%) and square (18%)²⁷ supporting that this anatomical guideline changes with race. Similar findings were reported by Kunihiro³¹ in his study on Caucasians and Japanese mandibular arch forms. Most frequent arch form was square in his Japanese group (45.6%), followed by ovoid (42.5%) and tapering (11.9%), a pattern similar to the Hispanic population.²⁷ In his Caucasian group, the tapering arches were most frequent (43.75%) followed by ovoid (38.1%) and square (18.1%) which is similar to results of Caucasian sample in the study by Gimlen.²⁷

In another study²⁸ diagnostic orthoform templates were used to determine the arch forms of Turkish sample, which reported tapering (62.5%) as the most prevalent arch followed by ovoid (27.33%) and square (10.2%). A study on Korean sample found ovoid (49.02%) to be the most frequent followed by square (42.06%) and tapering (8.82%).²⁹ The results of the Korean sample are comparable to the present study for ovoid arch forms, but reverse for tapering and square.

The results of a recent study on Caucasian population using subjective method for arch form evaluation reports that the most frequent arch form was ovoid 41%, closely followed by squarish 39% with only 20% tapering arches.³² This is in contrast to the studies by Kunihiro³¹ and Gimlen,²⁷ which employed diagnostic templates and reported tapering arches as the most frequent one in Caucasians. This observation is supporting the view that different methods of assessing the arch form may produce different results.

Very few studies using the mathematical formula proposed by Noorozi were found in the literature^{4,22,33} but none of them used this formula on the mandibular

arches. Due to this reason, a direct comparison is not possible. Interestingly, similar frequency distribution of arch forms in maxilla and mandible is noted in the above cited studies which used Noorozi's mathematical formula.

In the present study on mandibular arch forms ovoid arches are found in 74% of the sample, similar frequency is found in studies on the maxillary arches i.e. of 73.3%³³ and 82%.²² The tapering arch forms are found in 12% of the subjects of present study, in the studies on maxillary arches the results were 12.7% and 12% respectively. Similarly in the present study, square arch form is 14%, comparable results were reported in one study 14%³³ whereas the other study only reported 6.4%²². A parallel observation is made when the results of arch forms described by templates in the present study were compared to the result of the previous study by the same authors on maxillary cast. The frequency was 56%, 7% and 37% in the present study and 53.2%, 9.2% and 37.6% respectively for ovoid, square and tapering arches in the previous study.²²

Present study shows that both methods have 82.1% agreement on ovoid, 21.6% on tapering and 71.4% on square arch forms. Similarly in the previous study²² it was 87% on ovoid, 0% on square and 5.3 % on tapering arches. This supports the observation that when used simultaneously on the same sample, Diagnostic orthoform templates and Noorozi's formula do not complement each other. Never the less, results of diagnostic orthoform templates are comparable to results of other studies employing these templates, same is observed for Noorozi's method.

Furthermore, it may be assumed that maxillary and the mandibular arches may have similar frequencies of arch forms. However these observations need more studies for confirmation.

This study has the limitation of not investigating the reliability and validity of these methods and therefore a better method cannot be suggested. Variations in arch forms related to gender and Angle's classes have not been considered as both factors have shown not to influence the arch forms.^{20,31} Considering the importance of arch form in both Prosthodontics and Orthodontics, more studies comparing different methods of arch form analysis are suggested so a gold standard may be established. Further studies are suggested to evaluate arch forms in different ethnic groups of Pakistan and to compare the arch forms of maxilla and mandible.

CONCLUSION

According to both methods, the most common arch form was ovoid. There was a difference in frequency distribution of three arch forms by both methods. There is a statistically significant difference (p-value <0.001) in the results of both methods.

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