

## ORIGINAL RESEARCH

# Is It Possible to use Cross-sectional and Vertical Facial Measurements to establish the Shape of the Mandibular Arch?

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## ABSTRACT

**Background:** Given the benefits of radiographic cephalometric studies in determining patterns of dental-skeletal-facial normality in orthodontics, the aim of this study was to investigate the association between mandibular dental arch shape and cross-sectional and vertical facial measurements.

**Materials and methods:** It was analyzed plaster casts and telerradiographs in frontal and lateral norm belonging to 50 individuals, aged between 15 and 19 years, with no previous history of orthodontic treatment and falling into four of the six Andrews's occlusion keys. The plaster models were scanned (3D) and the images of the dental arches were classified subjectively as oval, triangular and quadrangular by three calibrated examiners, with moderate inter-examiner agreement (Kappa = 0.50). After evaluation of the method error by paired t test ( $p > 0.05$ ), it was carried out the analysis of cross-sectional and vertical facial measurements to be compared to the shape of the dental arch. Data were subjected to one-way analysis of variance with a significance level of 5%.

**Results:** When the VERT index was compared with the three arch shapes, no measurement showed statistically significant differences ( $p > 0.05$ ): triangular (0.54); oval (0.43); and quadrangular (0.73); as well as there were no differences ( $p > 0.05$ ) in the widths of the face (141.20; 141.26; 143.27); maxilla (77.27; 77.57; 78.59) and mandible (105.13; 103.96; 104.28).

**Conclusion:** It can be concluded that there was no correlation between different shapes of the mandibular dental arch and the cross-sectional and vertical facial measurements investigated.

**Keywords:** Cephalometry, Morphometrics, Stability and retention, Treatment planning.

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## INTRODUCTION

The dental arch is an important element in the establishment of diagnosis and implementation of the treatment plan in orthodontics.<sup>1</sup> Although most of the patients with malocclusion have their dental arches shapes altered, the modifications achieved by orthodontic mechanics should not affect the balance between muscle, bone and dental structures, as the arrangement of these structures adjacent to the teeth and maxillary bones should be considered the boundary for orthodontic treatment.<sup>2</sup>

The preservation of the inter-canine distance and of the dimensions of the arch shape obtained by proper management of arches in orthodontic treatment is a key element to achieve functional and stable outcomes. If these variables are neglected, there are higher chances of occurrence of crowding in the lower incisors, as well as root and alveolar bone resorption, dental inclination, periodontal damages and esthetic impairment.<sup>3</sup> Hence, many practitioners feel insecure before orthodontic treatment using pre-contoured wires in the alignment and leveling phases, since these do not present any kind of customization for the different types of dental arches.

The shape of the dental arch has been basically determined by two methods: subjective evaluation/classification and objective analysis.<sup>4</sup> The method of subjective classification is performed visually and categorizes the dental arches into three basic shapes: oval, triangular and quadrangular.<sup>5</sup> In the objective analysis, cross-sectional measurements of the dental arches are investigated, usually the inter-canines and inter-molars width.<sup>6</sup> The objective method also allows evaluating the plaster casts by means of numerical analysis, using mathematical equations to determine the ideal arch shape, including polynomial<sup>2,4</sup> and beta functions,<sup>7,8</sup> among others. The objective analysis by computed tomography was also a viable alternative, since the same arch shapes present in the plaster casts were found in the tomographs.<sup>9</sup>

Based on the need to establish an appropriate arch shape for greater customization of the orthodontic treatment proposed, and on the search for alternative methods

that assist in the determination of the arch shape during diagnosis, the aim of this study was to investigate the existence of correlation between morphology of the mandibular dental arch and cross-sectional and vertical measures of the face.

## MATERIALS AND METHODS

### Sample

This study was approved by the Ethics Committee of Methodist University of São Paulo (UMESP), São Bernardo do Campo, SP, Brazil under protocol 301916-09, assuring that the present research has followed ethical and legal principles.

The study subjects are part of a population of 13,618 students from the ABC region of São Paulo (SP, Brazil), who were selected by means of inclusion and exclusion criteria, totalizing a final sample of 50 individuals. The inclusion criteria were: (1) presence of normal natural occlusion-falling at least into four of the six keys of Andrews<sup>10</sup> (the first key was considered essential for sample selection) (2) individuals above 15 years of age; (3) presence of all permanent teeth in occlusion, except third molars. The exclusion criteria were: (1) history of previous orthodontic treatment; (2) presence of craniofacial malformations; (3) presence of significant facial asymmetry; (4) presence of odontogenic abnormalities.

This analytical observational study used plaster casts, and posterior-anterior and lateral telerradiographs belonging to the 50 individuals selected, who were Brazilian and leukoderma. Subsequently, they were classified according to their gender and age ranging. The mean age of the participants was 16 years and 6 months, ranging from 15 years and 2 months to 19 years and 4 months. Regarding gender, 20 patients (40.0%) were male and 30 (60.0%) were female.

### Collection and Analysis of Teleradiographs

Posterior-anterior (PA) and lateral telerradiographs were obtained for each patient, with maximum habitual intercuspation and lips at rest, assuring quality in the lip sealing. All radiographic examinations were performed by a single operator in X-ray equipment properly installed and calibrated according to radiometric reports used by the owning Institution (UMESP). All precautions were taken for the performance of a standardized, adequate and secure radiographic technique.

To standardize the radiographs, all patients were instructed to keep their heads in a natural position (NPH), looking into a mirror, standing a weight of one or one and a half kilogram in each hand.<sup>11</sup>

A total of 100 radiographs (50 in frontal norm and 50 in lateral norm) were scanned by a Hewlett Packard®

scanner model 4C (Palo Alto, California, USA), equipped with transparencies reader of the same brand, model ScanJet 6100/CT. The images obtained were imported into the software CefX® - Computerized Cephalometry (CDT, Cuiabá, MT, Brazil), run on Windows® operational system (Microsoft Corporation, Redmond, Washington, USA), where cephalometric tracings were accomplished.

For Ricketts frontal cephalometry,<sup>12</sup> the following points were demarcated: Za (external zygomatic point); J (intersection of the boundary of the maxillary tuberosity and zygomatic bone); and Ag (lower lateral margin of the gonion). The linear measurements used were: Za-Za (relative facial width); JJ (width of the maxillae on the cranial base); and Ag-Ag (width of the mandible base) (Fig. 1).

For lateral cephalometry, the points used were: Pr (porion); Pt (pterygomaxillary); Or (orbital); Na (nasion); Ba (basion); Dc (condylar axis); ENA (anterior nasal spine); Xi (center of mandible branch); Pm (mental protuberance); Po (pogonion); Gn (Gnathion); Me (mentonian) (Fig. 2).

The vertical measurements (Index VERT- name of the index that represents how the facial growth, suggested by Ricketts) used in lateral cephalometry were: Ba-Na.Pt-Gn (facial axis); Pr-Or.Na-Po (facial depth); Pr-Or.TangentMe (mandibular plane); Xi-ENA.Xi-Pm (lower facial height); Xi-Pm.Xi-Dc (mandibular arch) (Fig. 2).

The Ricketts analysis allowed determining the patient's facial type by means of measures related to the mandible, e.g. facial axis (FA); facial depth (FD); mandibular plane (MP); lower facial height (LFH) and mandibular arch (MA). The VERT index was obtained by the arithmetic mean of the difference between the measurement obtained from the patient and that normal for age, divided by the standard deviation. The signs (-) and (+) were used when the growth trend followed the vertical and horizontal directions, respectively. The results of each measurement were summed and divided by 5.

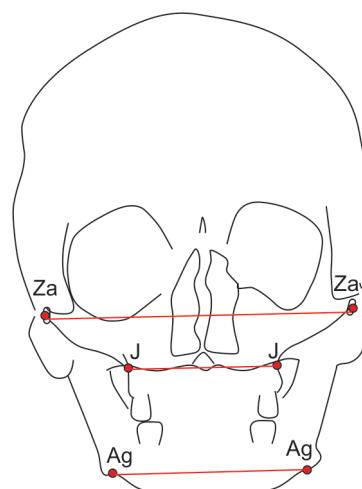


Fig. 1: Cross-sectional measurements used by Ricketts in frontal norm

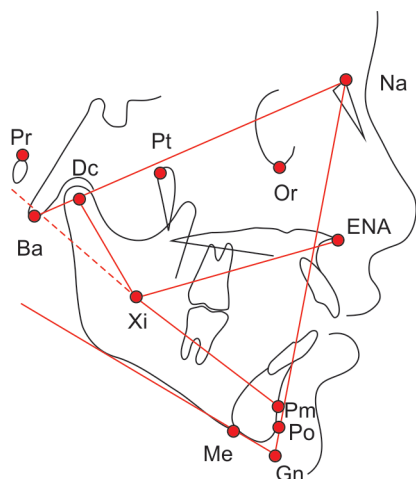


Fig. 2: Vertical measurements in lateral norm — Ricketts VERT index

### Tridimensional Scanning of Plaster Casts-3D Scanning

The 50 pairs of plaster casts were scanned by a 3D scanner of the brand Dental Wings® (Model DW5-140, Montreal, Quebec, Canada) belonging to the Hospital of the Face (São Paulo, Brazil), by an individual operator, previously trained. Equipment calibration followed the manufacturer's recommendations.

### Obtainment of the Dental Arches Shapes

After obtaining the images corresponding to the digitalized casts, it was used the Print Screen tool of the computer, converting the image obtained from the mandibular dental arch into a 72-dpi figure. These figures were transferred to the CorelDraw®X3 vector software (Microsoft Corporation, Redmond, Washington, USA), and Angle's line of occlusion was demarcated to determine the shape of the mandibular dental arch. To this end, the following elements were used as reference: incisal face of incisors; cusp tip of canines; buccal cusp tip of premolars and molars.

The images of the dental arches were printed on white paper below figures with pre-established models of arches, classified into quadrangular, oval and triangular, as previously described.<sup>5</sup> An album including all images of the arches belonging to the 50 individuals was distributed among three dentists, doctors in orthodontics, who checked individually the types of arches more similar to those presented in the casts. The examiners had a 1-week period to return the album completed to the researcher.

### Evaluation of the Method Error

For the evaluation of the intra-examiner method error, it was performed a second marking on radiographs in 20% of the sample, randomly selected within an interval of 30 days between the first and second measurement.

In order to check the intraexaminer systematic error, paired-t test was used. As for determining the random error, the following error calculation proposed by Dahlberg<sup>13</sup> was used:  $\text{Error} = \sqrt{\sum d^2 / 2n}$ , where  $d$  = difference between the 1st and 2nd measurements and  $n$  = number of radiographs retraced.

With regard to the classification of the mandibular dental arches, there was moderate interexaminer agreement verified by Kappa test<sup>14</sup> (Kappa = 0.50).

### STATISTICAL ANALYSIS

In order to verify if data followed a normal distribution curve, the Kolmogorov-Smirnov test was used ( $p > 0.2$ ). It was demonstrated that all variables had a normal distribution.

The evaluation of the effect of gender on the measures under study was performed by  $t$ -test, and the influence of individuals' age was verified by Pearson's correlation test. Statistical analysis of data regarding dental arch classification and linear and angular measurements was carried out by one-way analysis of variance.

A significance level of 5% ( $p < 0.05$ ) was adopted in all tests, and the statistical procedures were carried out on the software Statistica v.5.1 (StatSoft Inc., Tulsa, USA).

### RESULTS

The results of the systematic error evaluation, according to paired-t test, and those of the random error measured by Dahlberg's formula, are shown in Table 1.

There was no statistically significant difference for the cross-sectional and vertical facial measurements compared to the gender and correlated with age, as shown in Tables 2 and 3, respectively. Also, no statistically significant correlation was found when the measures evaluated were compared to the three arch shapes (Table 4).

### DISCUSSION

Across all areas of the health field, proper diagnosis is essential in establishing the treatment plan and specifically in orthodontics there is a constant search for knowledge about the best diagnostic tools. Thus, the present study had the purpose to find a possible correlation between measures that are routinely used in orthodontics, in order to assist in the selection of the mandibular dental arch shape closest to the ideal.

In the quest for excellence and stability in orthodontic treatments, experts have considered concepts of balance, i.e. it has been taken into account the boundaries of the mandibular arch. Therefore, importance has been given to the initial shape of the dental arch during treatment.<sup>12,15,16</sup> Some authors<sup>6,11,12,16-18</sup> have developed different techniques to determine the shape of the dental arch. Noroozi

**Table 1:** Mean and standard deviation of two measurements, paired t-test and Dahlberg's error used to evaluate the systematic and random errors ( $p < 0.05$ )

Measure	1st Measurement		2nd Measurement		T	p	Error
	Mean	SD	Mean	SD			
Maxillary width	82.37	3.35	82.25	3.40	1.593	0.126 NS	0.25
Mandibular width	77.69	3.41	77.59	3.45	1.605	0.124 NS	0.22
Facial width	4.68	2.09	4.66	1.98	0.324	0.749 NS	0.15

NS: Nonsignificant statistical difference; SD: Standard deviation

**Table 2:** Comparison between genders in the measures analyzed by t-test ( $p < 0.05$ )

Measure	Male		Female		Difference	p
	Mean	SD	Mean	SD		
VERT	0.76	1.34	0.45	0.95	-0.31	0.338 NS
Facial width	142.42	5.76	141.80	6.33	-0.63	0.724 NS
Maxillary width	78.48	3.93	77.53	3.50	-0.95	0.373 NS
Mandibular width	104.35	4.95	104.39	5.66	0.04	0.979 NS

NS: Nonsignificant statistical difference; SD: Standard deviation; VERT:

et al<sup>6</sup> point out that the most reported shapes of dental arches are: triangular, oval and quadrangular. This classification was used in the present study, as it is believed to be commonly used in the routine of clinical orthodontists.

The arrangement of prefabricated arches used in orthodontics may change the inter-canines distance in cases when they do not match. As subjects have different facial types and dental arch shapes, the inter-canine measures are not standardized. Triangular, oval and quadrangular are dental arch shapes commonly found. The dental movements performed should not either change this distance or the arch shape, achieving a stable and functional outcome. Hence, Kim et al<sup>3</sup> affirm that it is prudent to use prefabricated arches in the shape that best fits the dental arch shape, however, this customization is still not possible due to lack of size options available on the dental market.

Arai and Will<sup>4</sup> compared the methods of classification of arch shape through subjective evaluation performed

**Table 3:** Pearson correlation between age and the measures under analysis ( $p < 0.05$ )

Measure	R	p
VERT	0.16	0.261 NS
Facial width	-0.01	0.942 NS
Maxillary width	0.02	0.913 NS
Mandibular width	0.24	0.091 NS

NS: Nonsignificant statistical correlation; Index VERT– name of the index that represents how the facial growth, suggested by Ricketts

by examiners as well as objective analysis by means of measures of arch width and fourth order polynomial equation. Statistically significant associations were found between the types of evaluations, i.e. all methods for dental arch shape classification showed similar results. Accordingly, the identification of dental arch shape by examiners (subjectively) used in this study was found to be reliable.

Ansari et al<sup>9</sup> studied dental arch shapes using CT scans and could observe different features: subjects with quadrangular dental arch present alveolar bone thicker than others. Slaj et al<sup>18</sup> observed that the variability in the measures of the dental arch shapes is a common feature of all malocclusions.

Some studies<sup>1,12,19</sup> evaluated patients facial morphology using radiographs, and highlighted the importance of determining the facial type for a correct diagnosis. This has been shown to be important for the treatment/mechanics planning to be proceeded, but this was not efficient for the diagnosis of arch shape. A recent study<sup>20</sup> analyzed which angular measures would be better to determine the facial type of patients. In addition, SN.GoGn was suggested as the most suitable measure for defining the facial type. This study used the Ricketts VERT index to determine the facial type. It was used measures that when interpreted by a mathematical formula allow classifying the subject as dolichofacial, mesofacial and brachyfacial, in a more accurately way.

**Table 4:** Comparison of the measures studied and the three arch shapes analyzed by one-way ANOVA ( $p < 0.05$ )

Measure	Triangular		Oval		Quadrangular		p
	Mean	SD	Mean	SD	Mean	SD	
VERT	0.54	1.30	0.43	1.20	0.73	0.95	0.705 NS
Facial width	141.20	6.41	141.26	5.64	143.27	6.30	0.519 NS
Maxillary width	77.27	3.75	77.57	3.82	78.59	3.55	0.555 NS
Mandibular width	105.13	4.28	103.96	5.89	104.28	5.59	0.844 NS

ANOVA: Analysis of Variance; NS: Nonsignificant statistical difference; SD: Standard deviation



Kageyama et al<sup>7</sup> compared dental arch width according to different facial types (dolichofacial, mesofacial and brachyfacial) in adolescents aged between 11 and 16 years old, with class II Angle malocclusion. The authors observed a trend of dental arches to be wider in brachyfacial individuals and narrower in dolichofacial subjects. These findings do not corroborate those of the present study, which showed no significant association between dental arch shape and facial type.

The evaluation of the relationship between dental arch dimensions and facial type, determined by Jarabak analysis in orthodontically untreated patients, showed that dental arch dimensions are associated with facial morphology and gender.<sup>1</sup> The present study showed no statistical association between arch shape and cross-sectional and vertical facial measures. Nevertheless, both data remain essential factors in orthodontic diagnosis and should be evaluated together when determining treatment.

During the clinical care of orthodontic patients, many practitioners can identify a possible correlation between facial type and the different dental arch shapes, however, this fact could not be observed in the present study. It is believed that there is a need for a larger number of individuals in the sample. In addition, some important factors could have interfered with the composition of the sample in this study, which led to a lack of association between variables (e.g. ethnic differences and the inclusion criterion 'presence of normal natural occlusion'), since, other studies have shown that certain features may interfere with individual dental shape.<sup>18,21</sup>

Given the shortcomings of this study, further research is suggested to investigate other associations with different facial structures, in view of the quest for excellence in orthodontic treatment planning. It is necessary to check the need to use the three prefabricated arch shapes so that the shape and distances are closest to the ideal during dental movements.

According to the analysis of the data obtained from the study population, it can be concluded that in patients with normal natural occlusion, the mandibular dental arch shape was not associated with cross-section and vertical facial measurements (VERT Index). Thus, these measures do not support to determine the shape of the mandibular dental arch.

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