# EVALUATION OF SHAPE VARIATION OF MAXILLARY AND MANDIBULAR DENTAL ARCHES OF AN ORTHODONTIC POPULATION: AN ORIGINAL RESEARCH

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**ABSTRACT**

**Aim**

The purpose of the present research was to evaluate the variations in the shape of maxillary and mandibular dental arches in a population undergoing orthodontic treatment.

**Methodology**

Dental casts of 133 white subjects (61 males, 72 females; ages 10.6–26.6) were scanned and digitized in three dimensions. Landmarks were placed on the incisal margins and on the cusps of canines, premolars, and molars. Geometric morphometric methods were applied (Procrustessuperimposition and principal component analysis). Sexual dimorphism and allometry were evaluated with permutation tests and age–size and age–shape correlations were computed. Two block partial least squares analysis was used to assess covariation of shape.

**Results**

The first four principal components represented shape patterns that are often encountered and recognized in clinical practice, accounting for 6–31 per cent of total variance. No shape sexualdimorphism was found, nevertheless, there was statistically significant size difference betweenmales and females. Allometry was statistically significant, but low (upper: $R2$ = 0.0528, $P$ < 0.000, lower: $R2$ = 0.0587, $P$ < 0.000). Age and shape were weakly correlated (upper: $R2$ = 0.0370, $P$ = 0.0001, lower: $R2$ = 0.0587, $P$ = 0.0046). Upper and lower arches covaried significantly (RV coefficient: 33 per cent).

**Conclusion**
Covariation patterns showed that the dental arches were integrated in width and depth. Integration in the vertical dimension was weak, mainly restricted to maxillary canine position.
**Keywords** Dentistry, orthodontics, Arch form; Dental cast; Occlusion.

## INTRODUCTION

Dimensions of dental arches, including dental arches width, length, and shape, are important values for diagnosis, treatment planning, and treatment results about patients seeking orthodontic treatment in all age groups. Different ethnic groups and populations display variable dental arch measurements and characteristics. Thus, it is known that the dental arch dimension continues to change throughout growth and development; however, during adulthood, the change decreases. This explains why many researchers are interested in investigating changes in dental arch dimensions during each stage of growth and development.[1]In orthodontic treatment, dental arches are the main factor for achieving good occlusion in different environments and widths that are related to the processusalvolaris. Basically, the size and shape of the teeth are determined by the cartilaginous skeleton of the maxilla and mandible in the fetal period then develops. Tooth seeds and jawbones then grow. It is very important to classify and determine the relationship between craniofacial structures and the dimensions of dental arches.[2]The size of the dental arch has broad implications in orthodontics, especially in diagnosis and treatment plans in affecting available space, aesthetics, and tooth stability. The size of the transversal and sagittal dental arch in one individual is different from others; this is influenced by several factors, namely environment, genetic, race, and sex.[1,2] Changes in dental arches during growth and development are strongly influenced by growth and development of the processus alveolaris.[3] In general, the dental arch develop sat the mixed dentition stage and then tends to be stable until the permanent dentition. The dental arch of the mandible develops from the age of 4–8 years, whereas in the maxilla it takes from the age of 4–13 years and tends to be more stable in adulthood. Several studies have described and classified the size and shape of human dental arches. Differences in the size of the dental arch form are related to clinical treatment. Each ethnic group tends to have a different skeletal pattern, so the size and shape of the jaw in an ethnic group are different from other ethnic groups.[4,5]There is a controversy about dental arch configuration among authors using various methodologies.[6] However, most of the studies identified three main arch form shapes: tapered, ovoid and square. Generally, the ovoid dental form is the most commonly used in orthodontic practice (45% of individuals), followed by the tapered form (40%) while the square dental shape is the rarest (15%).[7] Furthermore, it was stated that a unique arch form cannot provide the best solution for an entire ethnic sample as different dental parameters should be considered; in particular, the main clinical factors that affect the dental arch dimensions are arch depth, cross-arch width and dental perimeter.[8] The arch shape consists of two different areas: the anterior curvature and intercanine width and posterior curvature and intermolar width.The maxillary and mandibular dental arches reside in the same environment and closely interact with each other for functional occlusion. In a population of normal (close to the ideal) occlusion, high covariation would be expected between the upper and lower arch; one arch would be sufficient to infer the precise position of the teeth of the opposing arch. In contrast, malocclusions show a much wider range of variations in arch form and individual tooth position, and covariation is presumably lower. Which covariation patterns remain strong and which fade away is a question that has not been investigated. Assessing the patterns of covariation in an orthodontic population could reveal which malocclusion features of the upper and lower arch are correlated and expected to co-occur, and which are relatively independent. By extension, covariation could unveil the scope of influence of the aetiological factors that contribute to the various aspects of the malocclusion.

## AIM OF THE PRESENT STUDY

The purpose of the present research was to evaluate the variations in the shape of maxillary and mandibular dental arches in a population undergoing orthodontic treatment.

## METHODOLOGY

In total, 133 patients, 61 males and 72 females were included in the present study. The maxillary and mandibular dental casts of each subject were scanned with a structured light 3D scanner. The landmarks chosen for digitization were the middle of the incisal edge of the central and lateral incisors, and the cusp tips of canines, first and second premolars, and first molars. Principal component analysis (PCA) was performed on the Procrustes coordinates to reveal the main patterns of dental arch shape variation. In order to determine the number of principal components (PCs) considered as statistically significant, we used three criteria: the broken-stick criterion, rnd-lambda, and the avg-rnd. Multivariate regression analysis was performed to investigate the relationship of shape variables (dependent variables: PCs) on size (independent variable: lnCS). Furthermore, regression analysis was performed to investigate the relationship of age on size, and age on shape. The analysis was conducted with MorphoJ softwareand covariation strength was evaluated by the RV coefficientTwenty scanned dental casts of both jaws were randomly selected and redigitized 10 days after the first digitization. Random error was expressed as the distance between repeated digitizations in shape space compared with the total variance of the sample.

## RESULTS

Mean random error of the 20 repeated digitizations, expressed as a percentage of total shape variance, was 2.39 per cent (range: 1.18–4.66 per cent, SD = 0.81 per cent) and 2.70 per cent (range: 1.01–4.82 per cent, SD = 0.84 per cent), for upper and lower arches, respectively.
There was no statistically significant difference in either upper or lower dental arch shapes between males and females (10 000 permutations, upper dental arch form $P = 0.098$, lower dental arch form $P = 0.117$). On the contrary, a statistically significant size difference in both dental arches was found between the genders. (Table 1)

**Table 1-Percent variance described by the first principal components that were considered to be statistically meaningful, in shape space and in form space**

| | Shape space (%) | Form space (%) | Shape space (%) | Form space (%) |
|---|---|---|---|---|
| PC1 | 31.0 | 38.3 | 31.5 | 41.5 |
| PC2 | 12.9 | 19.8 | 11.9 | 18.5 |
| PC3 | 9.1 | 6.0 | 7.8 | 5.0 |
| PC4 | 7.6 | 5.7 | 6.0 | 4.6 |
| PC5 | 5.7 | 5.0 | 4.3 | 3.7 |
| PC6 | 3.8 | 3.3 | 3.8 | — |
| PC7 | — | — | 3.5 | — |
| Sum | 70.1 | 78.1 | 68.8 | 73.3 |

A small-sized maxillary arch was related to high position of the canines; as size increases, the canines adopt a normal position within the arch. Likewise, in the mandibular arch, the position of the canine was mainly related to size, but in the horizontal instead of the vertical plane. The correlation between age and shape indicated that the arch width/arch length ratio increased as subjects get older, for both upper and lower dental arches, but the correlation was weak (upper: $R2 = 0.04$, $P = 0.0001$, lower: $R2 = 0.06$, $P = 0.005$, 10 000 permutations). The correlation between age and size suggested that the size of the dental arch tends to decrease as subjects get older, for both upper and lower dental arch, but this result was not statistically significant (upper: $R2 = 0.02$, $P = 0.1511$, lower: $R2 = 0.004$, $P= 0.483$). (Table 2)

**Table 2- Upper and lower dental arch form covariance**

| | % Total covariance |
|---|---|
| PLS1 | 80.23 |
| PLS2 | 10.99 |
| PLS3 | 2.33 |
| PLS4 | 1.71 |
| PLS5 | 0.94 |

**Two-block partial least squares analysis (2B-PLS). Overall strength of association between blocks: RV coefficient: 0.3332, P < 0.0001.*

## DISCUSSION

The arch shape is based on anatomic dimension of the alveolar ridge, on tooth eruption and perioral muscles.[9] Moreover, a diversity of dental arch shapes and dimensions in different ethnic groups was observed and several authors proposed geometric models in order to identify the mean configuration of the clinical arch shapes in different populations.[10]The sample of this study consisted of orthodontic patients, so the outcomes cannot be considered representative of the general population. Nevertheless, the sample included a wide spectrum of different malocclusions and a broad range of arch shape patterns. The choice of landmarks was based on the need to represent the arch form at the occlusal level, where higher correlation between arch forms was expected. Several points were used for the representation of the posterior teeth, thus providing more information about their spatial position and inclination. No statistically significant difference was detected between male and female shape. This is consistent with the results of other studies that used Euclidean distance matrix analysis. A statistically significant correlation was observed between age and shape: arch width/length ratio increased with age, for both upper, and lower dental arches.Studies investigating width changes at ages after the eruption of the second molar, as was our study, showed arch width increase in male subjects and decrease in females, decrease in all subjects, or slight to no change. Longitudinal studies have reported slight increases in arch width, but the changes were subtle and could be easily missed without serial data. A moderate increase in width of the dental arches can be expected, particularly in the anterior regions, until the permanent canines erupt. After this time, arch width usually decreases in both the anterior and posterior regions, as does arch length.[11]The RV coefficient, indicating the total extent of covariation, although statistically significant, was not strong. Approximately two thirds of the shape variation of the arches was independent of each other, thereby allowing a wide range of potential malocclusion configurations. It seems that apart from overall arch shape and width, which may be enforced by intercuspation and muscle equilibrium, different, and relatively independent aetiological factors determine tooth position in each arch. This finding may have clinical implications, indicating that different retention strategies may be appropriate for each arch.

ISSN 2515-8260 Volume 9, Issue 3, Winter 2022

## CONCLUSION

The main shape variation pattern, observed in both arches, was overall arch form, ranging from triangular to square. The other variation patterns were different and characteristic of each arch. Covariation was related to arch width and length and limited to about one-third of the total variance.

## REFERENCES

1. Ardani IG, Kannayyah D, Triwardhani A Correlation of maxillary and mandibular arch form and tooth size ratio in ethnicJavanese malocclusion patient. J Int Oral Health 2019;11:75-9.
2. Nahidh M, Ahmed NHA, Kadhum AS, AlattarAM The association between the facial and dental arch form. Int J Sci Res2017;6;659-63
3. Balaji H Dental arch patterns and its role in orthodontics: A review. Int J PharmacSci Health Care 2017;2:91-8.
4. Fleming PS Timing orthodontic treatment: Early or late? Aust Dent J 2017;62:11-9.
5. Worms FW, Speidel TM, Isaacson RJ, Meskin LH Pont's index and dental arch form. J Am Dent Assoc 1972;85:876-81.
6. Fujita K, Takada K, QianRong G, Shibata T. Patterning of human dental arch wire blanks using a vector quantization algorithm. Angle Orthod. 2002 Aug;72(4):285-94.
7. Slaj M, Spalj S, Jelusic D, Slaj M. Discriminant factor analysis of dental arch dimensions with 3-dimensional virtual models. Am J OrthodDentofacialOrthop. 2011 Nov;140(5):680-7.
8. Bhowmik SG, Hazare PV, Bhowmik H. Correlation of the arch forms of male and female subjects with those of preformed rectangular nickel-titanium arch wires. Am J OrthodDentofacialOrthop. 2012 Sep;142(3):364-73.
9. Triviño T, Siqueira DF, Scanavini MA. A new concept of mandibular dental arch forms with normal occlusion. Am J OrthodDentofacialOrthop. 2008 Jan;133(1):10.e15-22.
10. Collins BP, Harris EF. Arch form in American blacks and whites with malocclusions. J Tenn Dent Assoc. 1998 Jan;78(1):15-8.