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Is there any association between facial type and mandibular dental arch form in subjects with normal occlusion?

Luiz Renato Paranhos[1*], Adilson Luiz Ramos[2], Eduardo de Novaes Benedicto[3], Liliana Ávila Maltagliati[3], Maurício de Almeida Cardoso[4] and Leopoldino Capelozza Filho[4]

*[1]Núcleo de Odontologia, Universidade Federal de Sergipe, Rua Pe. Alvares Pitangueira, 248, 49400-000, Lagarto, Sergipe, Brazil. [2]Departamento de Odontologia, Universidade Estadual de Maringá, Maringá, Paraná, Brazil. [3]Clínica Privada, São Paulo, São Paulo, Brazil. [4]Departamento de Ciências da Saúde, Universidade Sagrado Coração, Bauru, São Paulo, Brazil. *Author for Correspondence: E-mail: paranhos@ortodontista.com.br*

ABSTRACT. The aim of this study was investigate the association between the mandibular arch morphology and the facial type of Brazilian Caucasians with natural normal occlusion. For this, we used a sample comprised of lateral radiographs and respective dental casts of 51 individuals (21 male and 30 female), presenting at least 4 of the 6 Andrews' keys to normal occlusion without previous orthodontic treatment. Angle's first molar relationship was considered indispensable for the sample. The facial type was defined by two cephalometric measurements (SN.SGn and SN.GoGn). After scanning the models (3D) and radiographs, the images were evaluated by 12 orthodontists. A modified Kappa test evaluated the agreement between examiners to classify the morphology of the dental arch. The chi-square test was used to verify the association between the facial type (dolichofacial, mesofacial, or brachyfacial) and the dental arch morphology (square, oval, or tapered), using significance level of 5%. Casual and systematic errors ($p > 0.05$) showed no significant results and the Kappa test showed significant agreement among examiners for the dental arch form (0.55) with a $p < 0.001$, considered as 'moderate'. The chi-square test indicated no significant association. The null hypothesis was accepted, as the facial type was not associated with dental arch morphology in individuals with normal occlusion.

Keywords: dental arch, face, morphology, cephalometry.

Existe alguma associação entre o tipo facial e a forma do arco dental mandibular em indivíduos com oclusão normal?

RESUMO. O objetivo do presente estudo foi verificar a associação entre a morfologia do arco dental mandibular e o tipo facial de brasileiros, leucodermas, com oclusão normal natural. Para isso, utilizou-se uma amostra consistiu de telerradiografias obtidas em norma lateral e os respectivos modelos em gesso de 51 indivíduos (21 do sexo masculino e 30 do feminino), com pelo menos quatro das seis chaves para oclusão normal de Andrews, sem histórico de tratamento ortodôntico prévio. A relação molar de Angle foi considerada indispensável para a amostra. O tipo facial foi definido por duas grandezas cefalométricas (SN.SGn e SN.GoGn). Depois de digitalizar os modelos (3D) e as radiografias, as imagens foram avaliadas por 12 ortodontistas. Para verificar a concordância entre os examinadores, quanto à classificação da morfologia do arco dental, foi utilizado o teste Kappa. O teste do qui-quadrado foi utilizado para verificar a associação entre o tipo facial (dolicofacial, mesofacial ou braquifacial) e a morfologia do arco dental mandibular (quadrangular, ovalar ou triangular), utilizando nível de significância de 5%. Erros casuais e sistemáticos ($p > 0,05$) não mostraram resultados significativos, e o teste Kappa mostrou concordância significativa entre os examinadores para a forma do arco dental (0,55), com $p < 0,001$, considerado como 'moderado'. O teste do qui-quadrado mostrou não haver associação estatisticamente significativa entre as variáveis. A hipótese nula foi aceita, já que o tipo facial não apresentou associação com a morfologia do arco dental em indivíduos com oclusão normal.

Palavras-chave: arco dental, face, morfologia, cefalometria.

Introduction

Treatment plan comes from a routine patient data collected. Among these data, vertical facial skeletal pattern comprises an essential item for an adequate diagnosis, since characterizing facial type, craniofacial growth can be described and quantified by means of dimensional, angular and topographical features. The facial skeletal pattern, often referred as facial type, when analyzed radiographically, can be classified as dolichofacial (more long and narrow face), brachyfacial (more shorter and wider face), and mesiofacial (intermediate type) (RICKETTS et al., 1979).

Facial morphology is defined and maintained during growth; under genetic control in determining the skeletal structure (BISHARA; AUGSPURGER JR., 1975). The facial type can be determined by subjective evaluation or by using cephalometric analyses, i.e., a set of measurements of the facial complex that shows the predominant direction of growth. Several authors described facial type analyses (RICKETTS et al., 1979; RIEDEL, 1952; SASSOUNI, 1955).

It was postulated that the facial type could determine dental arch form (AITCHISON, 1965; KAGEYAMA et al., 2006). Thus, orthodontists should respect facial type when choosing patient arch form.

Many classifications have been developed for describing the dental arch, but usually they are classified as tapered, oval, or square (FELTON et al., 1987; MCLAUGHLIN; BENNETT, 1999; NOJIMA et al., 2001; NOROOZI et al., 2001; SAVOSTIN-ASLING, 1980).

The dimensions of the dental arch are related to individuals and to evolutionary factors such as an increase in intercondylar distance of the cranial base. The arch form is determined during the embryonic period (BURDI, 1968).

Maintaining the initial mandibular arch form results in equilibrium between components of the stomatognathic system, possibly achieving greater long-term stability (TRIVIÑO et al., 2008).

Up to now, there were no solid confirmations relating arch form and facial type in normal occlusion subjects. Based on this premise, the aim of this study was to verify the hypothesis that the facial type of an individual is not associated to dental arch morphology.

Material and methods

The study was approved by the Research Ethics Committee of the Methodist University - UMESP (Protocol no. 281691 - 09).

This is an analytical observational study on initial sample comprising 95 lateral cephalometric radiographs taken with the same x-rays machine and operator with their respective dental casts carefully selected from 13,618 white students, in the department of orthodontics located in the Methodist University of São Paulo. Inclusion criteria were as follow: 15 years of age minimum, no previous orthodontic treatment. In addition, subjects' plaster models had to present normal occlusion with full dentition (except third molars), absence of crossbite, absence of open bite and at least 4 of the 6 Andrews' normal occlusion keys (ANDREWS, 1972). The first key (Angle Class I molar relation) was considered indispensable for selecting the sample and should be present in all cases. Based on these criteria, 95 individuals were selected.

Lateral cephalometric radiographs were digitized on a scanner, and the images were imported into the software CefX (Computer Cephalometry; CDT, Cuiabá, Mato Grosso State, Brazil) run on Microsoft Windows operating system. Then, angular measurements SN.GoGn and SN.SGn (RIEDEL, 1952; STEINER, 1959) were obtained. A previously calibrated orthodontist (LRP) realized all measurements.

Based on angular measurements, the subjects were classified as dolichofacial (SN.SGn > or = 70.1°), mesofacial (SN.SGn ≤ 70° and ≥ 64.1), and brachyfacial (SN.SGn < or = 64°), using the measurements suggested by Steiner (1959), and those evaluated by Riedel (1952), namely, dolichofacial (SN.GoGn > or = 37 ± 1°), mesofacial (SN.GoGn between 27° and 37°), and brachyfacial (SN.GoGn < or = 26.9°) as seen in Figure 1. Individuals who did not show coincident facial type diagnose between these measures were excluded from the sample. Thus, 51 individuals were analyzed, being 21 (41.2%) male and 30 (58.8%) female, with mean age of 16.6 years (range 15.2 to 19.4 years).

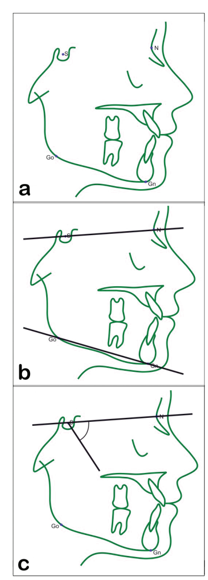

Figure 1. a) Cephalometric landmarks; b) angle measurements used (SN.GoGn) and; c) SN.SGn.

Dental casts were digitized by using a dw5-40, 3D scanner (Dental Wings, Montreal, Canada), previously calibrated according to the manufacturer's instructions. The nondestructive scanning captured the images of the models within a 3-axis Cartesian system (x, y, and z) by a laser beam and cameras inside the scanner. During this procedure the models were moved on a platform while the laser beam and cameras remained stationary. Using the Dental Wings software, 3D images were obtained with a resolution of approximately 0.2 mm and an accuracy of 20 to 50 microns. These were read using the software, 3Shape 3D Viewer (3Shape A/S, Copenhagen, Denmark).

From digital images of the casts, the print screen feature was used to transform the representation of each mandibular arch with high-resolution. These were transferred to vector software CorelDRAW X3, in which they were cropped and prepared for the study. Upon the lower cast, the following references were taken: the incisal edges of the incisors, the cuspids tips of the canines, and the buccal cuspids tips of the premolars and molars. Then Angle's line of occlusion and the morphology of the dental arch were obtained (Figure 2).

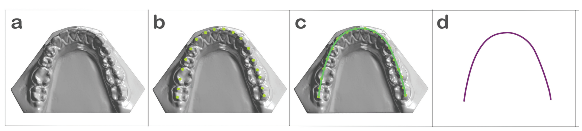

Figure 2. a) Image of the mandibular dental arch exported; b) Marking of the incisal edge of the incisors and cusp tip of mandibular canines, premolars and molars; c) Demarcation of Angle's line of occlusion; d) Final morphology of the mandibular dental arch.

The images of the dental arches were printed on white paper (90 g mm^{-2}). Each image was located in the center of the paper below the models of the pre-established dental arches, as suggested and classified by McLaughlin and Bennett (1999) (i.e., square, oval, or tapered). These were combined into a folder and distributed among 12 orthodontics, 7 female (58.33%) and 5 male individuals (41.67%), all of whom had a master's degree in orthodontics and selected after a pilot study. The specialists were requested to choose in each case the form that was most in accord with the models of the dental arch presented, following a methodology already used by our research group in recent studies (PARANHOS et al., 2012).

To evaluate the method error, a second evaluation was performed 2 weeks later on 20 lateral cephalometric radiographs randomly selected. A paired *t* test was run to check the systematic error. The casual error was measured with the Dahlberg formula. Correlation between examiners in classifying the morphology of the dental arch was evaluated by applying the modified Kappa test (LANDIS; KOCH, 1977). In order to verify whether there was an association between the facial skeletal pattern (dolichofacial, mesofacial, or brachyfacial) and dental arch morphology (square, oval, or tapered), the chi-squared test was used. All tests were calculated with a statistical significance level of 5%. All tests were performed with Windows StatSoft, version 5.1 (StatSoft, Tulsa, Okla).

Results

Casual and systematic errors ($p > 0.05$) showed no significant results, demonstrating method is precise and reproducible. The result of the Kappa test indicated a significant concordance among 12 examiners for the dental arch form (0.55) with a p value of <0.001, and the concordance value was 'moderate' (LANDIS; KOCH, 1977).

The dental arch form was defined as the most concordant opinion from evaluators. The chi-squared test showed no statistically significant association between the variables (Table 1).

Table 1. Association between the Facial Type and the dental arch form.

Facial Type		Arch Form			Total
		Oval	Square	Tapered	
Brachyfacial	n	12	9	3	24
	(%)	(50.0)	(37.5)	(12.5)	(100.0)
Mesofacial	n	5	6	3	14
	(%)	(35.7)	(42.9)	(21.4)	100
Dolichofacial	n	4	5	4	13
	(%)	(30.8)	(38.5)	(30.8)	(100.0)
Total	n	21	20	10	51
	(%)	(41.2)	(39.2)	(19.6)	(100.0)

χ^2 = 2,4381; p = 0,657 (non-significant).

Discussion

The orthodontists are trained to recognize symmetrical and regular shapes. These specialists were selected to carry out a subjective analysis of dental arch morphology. Berksun et al. (2002) applied a similar methodology. Visual analysis and selection of the dental arch was also used by other authors (FELTON et al., 1987; NOJIMA et al., 2001). The images obtained for these subjective analyses were acquired through 3-D scanning of dental casts, which is an accurate method, proven by several dental studies (BELL et al., 2003; ZILBERMAN et al., 2003).

The human face, along with its bony and muscular support, presents peculiar characteristics. Facial configuration is under the influence of various factors such as race, gender, heredity, genetics, environment, and the character of craniofacial growth. The facial growth, with the exception of the mandible, is concluded relatively early: 60% of craniofacial development occurs during the first 4 years of life and, by age 12, is 90% completed (MARMITT et al., 2009). Although facial appearance is established in early childhood, it presents some changes during the growth, especially in mesofacial subjects (BISHARA; AUGSPURGER JR., 1975). The mandible grows until maturity, when the surface acquires its final dimension. Growth preserves the dental and facial morphological features in both normal and abnormal occlusion (BISHARA; AUGSPURGER JR., 1975).

The facial type influences the treatment plan, especially since facial morphology can aggravate or mitigate the results of certain orthodontic procedures, interfering with both aesthetics and treatment stability. Facial analysis is accomplished through diverse methodologies of obtaining measurements, landmarks, and structures, which, in turn, lead to various diagnostic methods of determining the facial type. The most commonly used is cephalometrics, which measures craniofacial structures on lateral cephalometric radiographs.

Changing concepts of normality in contemporary orthodontics has led to new perspectives in diagnosis, prognosis, and treatment. However, changes made in procedures should not affect the balance between bones and muscular structure, because both malocclusion and normal occlusion present a natural, balanced equilibrium between teeth and bone, influenced by the surrounding muscles (STRANG, 1946). The intercuspid distance, in particular, must be little changed by orthodontic treatment (INTERLANDI, 1978; RICKETTS, 1978; STEADMAN, 1961; ZACHRISSON, 1998).

In the early years of orthodontics, the predominant philosophy was to expand the dental arches without concern about the balance between the remaining structures of the stomatognathic system (HOUSLEY et al., 2003; STRANG, 1946). Subsequently, it was found that excessive expansion remained stable only while retainer was used (HOUSLEY et al., 2003). After retainer removal, the distances between homologous teeth tended to return to values at the beginning treatment. However, any expansion or contraction of the dental arch remained after treatment when tooth positions did not alter the physiological function of the muscles (HOUSLEY et al., 2003; STEADMAN, 1961; STRANG, 1946).

Because of teeth tend to return to their original positions, their movement must be restricted, and the intercuspid, interpremolar, and intermolar distances should be respected during orthodontic therapy, since orthodontic movement does not establish the teeth in their new positions when there is no balance between muscle and bone structures (STEADMAN, 1961). McLaughlin and Bennett (1999) also stated that there is a strong tendency of teeth to return to their initial positions after removal of orthodontic appliances. Always searching for excellent treatment results, specialists started to consider the concepts of equilibrium and orthodontic treatment planning that respects the limits of the mandibular arch. They have started to give importance to the initial configuration of the dental arch throughout treatment, because investigators have proven that this factor has a strong influence on the results and stability of treated cases (BOONE, 1963; MCLAUGHLIN; BENNETT, 1999). The use of models or references to help the professional in archwire construction or in the selection of pre-contoured archwires have also been suggested (CURRIER, 1969; STRANG, 1946). These models, which describe arch form by means of diagrams based on measurements of key points on the dental arch, would provide parameters from the beginning to the end of treatment. With the use of a custom diagram for patients, archwires can be constructed with a standardized format and dimensions, maintaining lateral and anteroposterior distances during treatment.

Various methodologies have been used to reproduce the dental arch form. Some authors have advocated photocopying plaster models for subsequent visual selection of the form, then using pre-contoured archwires from different manufacturers (FELTON et al., 1987). Another option is to apply Cartesian coordinates to models on which the x and y axes can be identified. Using this system with photocopies to visualize the arch form, the clinician can choose among 3 previously established forms, square, tapered, and oval (NOJIMA et al., 2001). Recently some authors have advocated digitizing natural, normal occlusion models and applying mathematic formulas to establish dental arch form (ALHARBI et al., 2008; TRIVIÑO et al., 2008). In this way, regardless of the complexity of the method used for determining and selecting the shape of the arch, the final choice of the form should be visual and therefore subjective.

Several authors have found more than one form of dental arch (CURRIER, 1969; MCLAUGHLIN; BENNETT, 1999; NOROOZI et al., 2001; SAVOSTIN-ASLING, 1980), however, there is disagreement as to the number of shapes found. Despite the agreement between authors about the variety of forms to better describe the dental arch, the differences occurred mainly because of the research methodology, in addition to ethnic differences in the samples studied, as well as presence of malocclusion.

Use of the 3 forms originated in 1934 (CHUCK, 1934), and its goal has been to improve and individualize arch form and to facilitate treatment planning. The quadratic arch forms more suitable for a wide arch that needs to maintain the post-treatment morphology of rapid or slow expansion. It presents a flattening in the anterior region of the curve, placing the central and lateral incisors in almost a straight line as well as providing verticalization of the posterior segment. The tapered form, on the other hand, is used for narrow dental arches, having a smaller intercuspid distance. The ovoid form, often used by orthodontists, has an intercuspid distance somewhat wider than the tapered form.

At the beginning of orthodontic treatment, during the leveling and alignment phase with elastic archwires, the use of a single form facilitates clinical procedures and decreases the inventory of material needed. After this phase it is essential to assess the patient's initial mandibular arch form (tapered, oval, or square) in order to use the most appropriate in contouring the archwires throughout therapy, thus significantly contributing to the post-treatment stability (INTERLANDI, 1978; IZARD, 1927; MCLAUGHLIN; BENNETT, 1999; RICKETTS, 1978; STEADMAN, 1961; STRANG, 1946; TRIVIÑO et al., 2008; ZACHRISSON, 1998).

It was suggested that individuals with a short face (brachyfacial) tend to have excessively wide arches, while narrow arches are characteristic of dolichofacial types (AITCHISON, 1965; KAGEYAMA et al., 2006). These studies disagree with our study wherein no statistically significant association was detected between the facial type and lower dental arch morphology (Table 1). Although not significant, it is interesting to note that ovoid arches were more prevalent in brachyfacial individuals, the square form in mesofacial types, and the tapered arch in dolichofacial individuals (Table 1).

Ethnic differences influence the size and shape of the teeth and arches, as shown in previous studies (FERRARIO et al., 1999; NOJIMA et al., 2001). Using sophisticated methods of overlapping images, they verified the correlation between 4 aesthetic factors: facial morphology, dental morphology, dental arch form, and palatal contour (SELLEN et al., 1998). The best match took place between arch form and facial morphology, however it was quite low (28%).

A few years later, Berksun et al. (2002) through digital photographs, verified a subjective correlation between facial morphology and dental arches, without any expressive correlation. However, the correlation between the face and dental arch form was 54%, but examiners have not found a satisfactory concordance.

Braun et al. (1999) had alert NiTi archwires manufacturers to adequate preformed wires into more like normal occlusion arch forms. In their study intercuspid distance from preformed NiTi archwires were in average 5.95 mm larger than normal occlusion arches. NiTi archwire forms did not matched natural dental arches as well.

It seems reasonable to affirm that goals established for treatment should be incorporated into the arch form for each particular patient thus, it is not recommended to consider any single form as 'ideal'.

Based on the results, no statistically significant association was found between the facial type and mandibular dental arch morphology (Table 1). Consequently, the use of the facial type as a method of diagnosis to determine the morphology of the dental arch is not appropriate. Further research is required to assess mandibular arch form using evidence-based orthodontics.

Conclusion

The null hypothesis was accepted. Thus, the facial type had not been associated, according with the methodology used, with the dental arch morphology in individuals with natural normal occlusion.

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