Relationship between the morphology of the maxillary central incisor and horizontal and vertical measurements of the face

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ABSTRACT

Purpose: In order to assist in the selection of artificial teeth for complete dentures, this study aimed to assess the relationship between horizontal and vertical measurements of the face and the morphology of the maxillary central incisor.
Materials and Methods: This was a study of 50 plaster casts and 100 teleradiographs - 50 in lateral norm and 50 in frontal norm, belonging to 50 individuals, Caucasian, with a naturally optimal occlusion, matching at least four of the six keys of Andrews. Images of the upper central incisors were obtained by scanning the plaster casts (three-dimensional) and subjectively classified by three examiners as oval, triangular or quadrangular. Facial measures (vertical and horizontal) were defined by means of teleradiographs. In order to check inter-examiner agreement on the classification of central incisor, the Kappa test was used. To verify whether data had normal distribution, the Kolmogorov–Smirnov test was used ($P > 0.2$) was used. One-way analysis of variance was employed to assess the association between variables ($P > 0.05$).
Results: When vertical measurements were compared with the three incisor shapes, there was no statistically significant difference ($P > 0.05$): Triangular (0.54), oval (0.63) and quadrangular (0.51). Similarly, no difference ($P > 0.05$) was found for facial width (139.08, 143.37, 141.65), maxillary width (76.68, 78.99, 76.91) and mandibular width (103.47, 105.50, 103.11).
Conclusions: The majority of cases showed that horizontal and vertical measurements of the face cannot be used as a reference for determining the morphology of the maxillary central incisor crown. It is relevant to analyze and compare other morphological structures to improve the oral health-related quality of life for the conventional denture wearer.

Key words: Cephalometry, face, form perception, tooth

Given the aging of the population, there has been a greater demand for restorative procedures performed by dental professionals.[1] Even when a prosthesis is fabricated properly, providing comfort and restoring function, it can be rejected by the patient if it does not resemble as much as possible natural teeth.[2] As such, esthetics is always thought as one of the principles of oral rehabilitation. Hence, the selection of artificial teeth is one of the most critical steps during prosthetic rehabilitation of edentulous patients.[3] In addition, the proper choice of the maxillary incisor shape can contribute significantly to achieving greater facial harmony.[4]

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A large number of facial structures have been reported as useful in the selection of anterior teeth.[2,3,5-8] Nevertheless, there is no consensus in the literature regarding the method to be used for this purpose.[9,10] Researchers have stated that although observation of remaining teeth and preextraction records may be more efficient, smile aesthetics is not only restricted to the teeth as face morphology provides relevant information to this function.[6,11] However, measures used as guides for the replacement of anterior teeth are usually based on soft tissues, which are easily altered by factors such as age and weight.[6] Hence, the use of less variable anatomical landmarks is more indicated in the selection of anterior teeth.[12]

A study by Câmara[13] correlated facial measures with central incisors dimensions. According to this author, wide faces should be restored using wide teeth, while for narrow faces, narrow teeth are preferable.

It is known that the selection of dental shape has been object of study for many years targeting facial harmony and satisfactory esthetics, especially in oral rehabilitation. Dental specialties such as prosthodontics, radiology, and orthodontics, have made possible to assess and recognize the morphological requirements that affect and influence dental and facial esthetics of each single person.[14] It is important to consider an authentic anatomic reconstruction accepted by the patient for subsequent success of the rehabilitation treatment, as in addition to the function, esthetics is a crucial factor to be considered. Moreover, given that the existing methods for this selection are still under debate and there is no consensus in the literature on the best method for analysis, it was tested the hypothesis of an association between facial measures (horizontal and vertical) with the central incisor morphology.

MATERIALS AND METHODS

Sample

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

The sample consisted of Brazilian Caucasian individuals. These study subjects were part of a population of 13,618 students from the "ABC" region of São Paulo (SP, Brazil), who were selected by inclusion and exclusion criteria, totalizing a final sample of 50 individuals. This analytical observational study used plaster casts, and posterior-anterior and lateral teleradiographs belonging to 50 individuals selected, classified according to gender and age range.

The inclusion criteria established were: (1) Presence of normal natural occlusion (naturally optimal occlusion) - occlusion should fall at least into four of the six keys of occlusion defined by Andrews;[15] the inter-arch relationship, which is the first of the keys of occlusion by Andrews, should be mandatory in all cases; (2) individuals above 15 years of age; (3) presence of all permanent teeth in occlusion, except third molars; (4) presence of sound and healthy teeth clinically evaluated.

The exclusion criteria were: (1) History of previous orthodontic treatment; (2) presence of craniofacial malformations (congenital abnormality involving the region of the cranium and face, in which the most common craniofacial abnormality is cleft lip and/or palate); (3) presence of significant facial asymmetry clinically evaluated; (4) presence of odontogenic abnormalities related to size, shape and number.

Collection and analysis of teleradiographs

Posterior-anterior and lateral teleradiographs were obtained for each patient, with maximum habitual intercuspation and lips at rest. In order to standardize the radiographs, all patients were instructed to keep their heads in a natural position, as described in previous studies,[16] looking into a mirror while holding a weight of one or one and a half kilogram in each hand.

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). The images obtained were imported into a software for computerized cephalometric analysis. The software used was CefX® (CDT, Cuiabá, MT, Brazil) running on Windows® operational system (Microsoft).

The points used in Ricketts *et al*. frontal cephalometry[17] were: 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) [Figure 1].

For the 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) [Figure 2].

The vertical measurements used in the lateral cephalometry (VERT index of Ricketts *et al*.[17]) were: Ba-Na.Pt-Gn (facial axis [FA]); Pr-Or.Na-Po (facial depth [FD]); Pr-Or.TangentMe (mandibular plane [MP]);

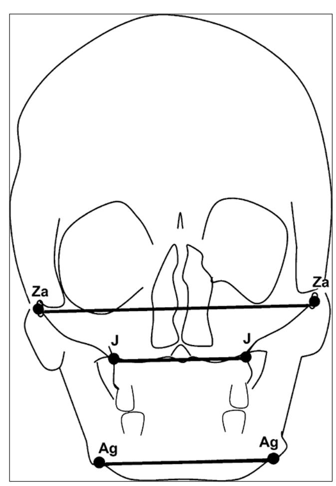

Figure 1: Cephalometric points and linear measurements

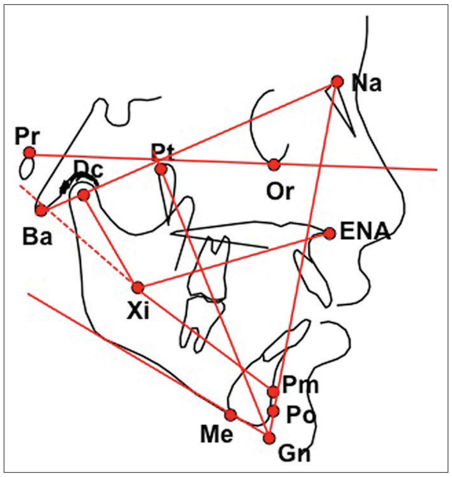

Figure 2: Points in lateral norm and vertical measurements

Xi-ENA.Xi-Pm (lower facial height [LFH]); Xi-Pm. Xi-Dc (mandibular arch [MA]) [Figure 2].

The Ricketts *et al.*[17] analysis allowed determining the patient's facial type by means of measures related to the mandible, e.g. FA; FD; MP; LFH and MA. The VERT index was obtained by the arithmetic mean of the difference between the measurement obtained from the patient and that considered normal for the age, divided by the standard deviation. The signs (–) and (+) were used when the growth tendency followed the vertical and horizontal directions, respectively. The result of each measurement was summed and divided by 5.

Tridimensional scanning of plaster casts - three-dimensional scanning

In order to obtain the plaster models, patients were molded with fast-setting alginate Zhermarck (Hydrogume, Polesine Badia, Italy); then molds were poured in Asfer type III plaster (Asfer, Curitiba, PR, Brazil).

The 50 pairs of plaster casts were scanned by a three-dimensional scanner of the brand Dental Wings® (Model DW5-140, Montreal, Quebec, Canada) belonging to the Hospital of the Face (São Paulo/SP - Brazil). Equipment calibration followed manufacturer's recommendations.

Morphology of the maxillary central incisor

After obtaining the images (digitalized casts), it was used the Print Screen tool of the computer, which made possible to convert the image obtained from the mandibular dental arch into a 72-dpi figure. In order to improve the visualization, the image of the right maxillary central incisor was resized to 10 cm and set in negative, with a dark background. After that, the images were printed in the center of a 90 g/m^2 white paper below preset models of dental crowns (oval, triangular and quadrangular) [Figure 3], as previously reported.[4] Hence, an album including all images of the central incisors was distributed among three dentists previously trained, who individually checked the shape more similar to that presented in the casts. The examiners had a 1-week period to return the album completed to the researcher.

Analysis of the method error

For the evaluation of the intra-examiner method error, a second mark was made in 30% of the teleradiographs randomly selected within an interval of 30 days between the first and second measurements. In order to check the intra-examiner systematic error, paired *t*-test was used. As for determining the random error, the following error calculation proposed by Dahlberg[18] was used: $\text{Error} = \sqrt{\sum d^2/2n}$, where d = Difference between the 1st and 2nd measurements and n = Number of radiographs retraced.

System and casual errors tests showed no statistically significant results, demonstrating a good reliability of the method ($P < 0.05$) [Table 1]. The results of the Kappa test showed significant concordance for tooth shape ($k = 0.42$) ($P < 0.05$). According to Landis and Koch,[19] the concordance value can be considered as "moderate."

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 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 morphology classification and linear and angular measurements was carried out using one-way analysis of variance. A 5% significance level was adopted for all tests and calculations were made using statistics for Windows® version 5.1 (StatSoft Inc., Tulsa, OK, USA).

RESULTS

Tooth shapes were chosen based on the opinions of most part of the examiners, as it was not aimed to calculate an average, but only to correlate tooth shape with horizontal and vertical measurements of the face.

The subjects had a mean age of 16 years and 6 months, ranging from 15 years and 2 months to 19 years and 4 months. Regarding gender, 20 (40.0%) were male and 30 (60.0%) were female. According to Student's *t*-test, there were no significant statistical differences for the correlation of horizontal and vertical measurements of the face with gender [Table 2] and age [Table 3].

The analysis of variance showed no statistically significant association between the VERT index and horizontal measurements of the face with the incisors shapes studied [Table 4].

Figure 3: Dental morphology: (a) Quadrangular tooth; (b) oval tooth; and (c) triangular tooth

Table 1: Mean and SD of two measurements, paired *t*-test and Dahlberg's error used to evaluate the systematic and random errors

Measure	1st measurement		2nd measurement		*T*	*P*	Error
	Mean (mm)	SD	Mean (mm)	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 for the measures analyzed

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=Index of Ricketts represents the vertical measurements used in lateral cephalometric

Table 3: Pearson correlation between age and the measures under analysis

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, VERT= Index of Ricketts represents the vertical measurements used in lateral cephalometric

Table 4: Comparison between the measures studied and the three tooth shapes

Measure	Triangular		Oval		Quadrangular		*P*
	Mean	SD	Mean	SD	Mean	SD	
VERT	0.54	1.19	0.63	1.10	0.51	1.19	0.946 ns
Facial width	139.08	3.72	143.37	5.98	141.65	6.84	0.182 ns
Maxillary width	76.68	3.53	78.99	3.89	76.91	3.01	0.111 ns
Mandibular width	103.47	6.11	105.50	4.75	103.11	5.72	0.330 ns

ns=Nonsignificant statistical difference, SD=Standard deviation, VERT= Index of Ricketts represents the vertical measurements used in lateral cephalometric

DISCUSSION

Diagnosis in dentistry as well as in other areas of medicine requires an appropriate data collection and hence that professionals can establish therapeutic goals consistent with specific limitations for each treatment. Since the last century, authors[20-24] have sought objective and subjective methods to establish standards and anatomical associations that assist to understand the morphological nature of every human being.

The introduction of cephalometric analysis by Broadbent,[25] in 1934, brought about a clinical and research tool for understanding the vertical and horizontal growth and development of human face. If there is proportionality between the vertical and horizontal vectors, the individual develops in a balanced way.[21-26] Ricketts *et al.*[26] classified the facial growth pattern as dolichofacial, mesofacial, and brachyfacial. As a way to assist in determining the facial type of each patient, the authors developed the VERT index. The advantage of this diagnostic tool is to use not one but five angular values for this function, thus reducing the possibility of misinterpretation, for instance, due to a failure in determining a cephalometric point or to an anatomical variation not consistent with a particular facial pattern. The VERT index can indicate positive and negative values. Hence, the mean is expected to be a value close to zero, as found in the present study. Therefore, it is normal that variability is higher than the mean.

Similarly to profile radiographs, in anterior-posterior images it is possible to pinpoint specific anatomical structures and establish a relationship between them to aid in the diagnosis of the individual's facial morphological nature.[26]

An aligned smile obeying to aesthetic standards is a shared desire for dental professionals and their patients. In this respect, Hasanreisoglu *et al.*[27] have reported that the size and shape of the anterior teeth are critical features. Câmara[13] stressed the importance of obtaining parameters and standards that allow the dentist to respect unique anatomical features, even in the absence of information prior to the loss of these teeth.

Hence, several studies[2-5] have shown difficulty to estimate artificial teeth dimensions. In addition, they point out that an incorrect selection of teeth impairs the denture aesthetics, interfering with the success of the rehabilitation treatment.

The analysis and visual selection of the incisor morphology was proposed almost a century ago[28] and revised by Sellen *et al*.[9] The collection of images for the subjective assessment of the incisor shape was performed by three-dimensional scanning of plaster models. This methodology has been proven to be reliable according to many studies.[29-31]

It is known that one of the greatest difficulties in the process of oral rehabilitation in edentulous patients is to restore aesthetics and function satisfactorily. Records prior to extractions such as photographs and plaster models are frequently used. These records facilitate the reproduction of suitable size of the anterior dental segment. Unfortunately, some individuals do not have such information, and the use of facial references in dental anatomical reconstruction becomes fundamental in this process.[5,10] Authors[2,5,10] affirm that the lack of similarity between artificial teeth and natural teeth can lead the patient to reject the denture.

Studies[2,3,5-8] correlated the shape of the maxillary central incisor with facial shape. Joly *et al*.[11] also emphasized the importance of the face in the selection and aesthetics of the smile. Furthermore, according to the authors, the analysis of the face is critical to determine symmetry, harmony and facial and dental proportions.

In this study, it was not found a reliable relationship between the widths of the face, maxilla and zygomatic and the incisor shapes studied. In their study Gomes *et al*.[10] they found a relationship between the interalar distance and the width of the maxillary anterior teeth. Al Wazzan[5] reported a relatively weak correlation between the inter-canthal distance and the width of maxillary incisors. Almeida *et al*.[6] in a literature review found that the inverted shape of the face is the best way to determine the shape of the maxillary central incisor.

Ellakwa *et al*.[7] found a relationship, albeit weak, between extra-oral distances (inter-canthal, inter-pupillary, interalar, inter-commissure) and the width of the maxillary central incisors. Pedrosa *et al*.[8] checked the correlation between facial width and incisor shape, finding positive results.

Unlike the previously mentioned authors, through a subjective evaluation Koralakunte and Budihal[32] failed to find a relationship between the shape of the face and that of the maxillary central incisor in an Indian population. However, it is difficult to establish reliable anatomical references when standardized radiological examinations are not used, such as cephalometric radiographs. This is valid for methodologies of studies performed with the aid of photographs sometimes associated with intra- and extra-oral measurements.

Nevertheless, there are no reports in the literature regarding the relationship between horizontal measurements advocated by Ricketts *et al*.[26] and the shape of maxillary central incisors.

Some important factors may have affected the composition of the study sample, which led to a lack of association of variables such as the inclusion criteria normal natural occlusion. Koralakunte and Budihal[32] stated that polygenetic factors and miscegenation of the Indian population might have influenced their findings. The same situation may have happened in the present study, because the Brazilian population has similar characteristics.

Within the limitations of this study, it was observed that in people with normal natural occlusion there were no statistically significant associations between horizontal and vertical measurements and the maxillary central incisor morphology. This study leaves a scope for further research to analyze and compare other morphological structures, in order to improve the oral health-related quality of life for the conventional denture wearer.

REFERENCES

1. Felton DA. Edentulism and comorbid factors. J Prosthodont 2009;18:88-96.
2. Gomes VL, Gonçalves LC, do Prado CJ, Junior IL, de Lima Lucas B. Correlation between facial measurements and the mesiodistal width of the maxillary anterior teeth. J Esthet Restor Dent 2006;18:196-205.
3. Isa ZM, Tawfiq OF, Noor NM, Shamsudheen MI, Rijal OM. Regression methods to investigate the relationship between facial measurements and widths of the maxillary anterior teeth. J Prosthet Dent 2010;103:182-8.
4. Paranhos LR, Jóias RP, Velasco LG, Berzin F, Daruge-Júnior D. Prevalence of the different maxillary central incisor shapes in individuals with natural normal occlusion. Braz J Oral Sci 2010;9:104-7.
5. Al Wazzan KA. The relationship between intercanthal dimension and the widths of maxillary anterior teeth. J Prosthet Dent 2001;86:608-12.
6. Almeida RK, Magalhães MP, Kaieda AK, Kairalla SA, Torres FC, Paranhos LR. The upper central incisor shape in the literature viewpoint. Journal of the Faculty of Dentistry. University of Passo Fundo.2011;16:337-41.
7. Ellakwa A, McNamara K, Sandhu J, James K, Arora A, Klineberg I, *et al*. Quantifying the selection of maxillary anterior teeth using intraoral and extraoral anatomical landmarks. J Contemp Dent Pract 2011;12:414-21.
8. Pedrosa VO, França FM, Flório FM, Basting RT. Study of the morpho-dimensional relationship between the maxillary central incisors and the face. Braz Oral Res 2011;25:210-6.
9. Sellen PN, Jagger DC, Harrison A. Methods used to select artificial anterior teeth for the edentulous patient: A historical overview. Int J Prosthodont 1999;12:51-8.
10. Gomes VL, Gonçalves LC, Costa MM, Lucas Bde L. Interalar distance to estimate the combined width of the six maxillary anterior teeth in oral rehabilitation treatment. J Esthet Restor Dent 2009;21:26-35.
11. Joly JC, Mesquita PF, Silva RC. Reconstruction tissue aesthetics-Procedures and plastic regenerative periodontal and peri-implant. 1st ed. São Paulo: Artes Médicas; 2010.
12. Guldag MU, Büyükkaplan US, Sentut F, Ceylan G. Relationship between pterygomaxillary notches and maxillary anterior teeth. J Prosthodont 2010;19:231-4.
13. Câmara CA. Aesthetics in orthodontics: Diagrams of facial aesthetic references (DFAR) and diagrams of dental aesthetic references (DDAR). Rev Dent Press Ortod Ortop 2006;11:130-56.
14. Câmara CA, Fonseca DM. Interdisciplinary treatment: Esthetic approach of unusual orthodontics cases. Rev Dent Press Ortod Ortop Facial 2000;5:68-74.
15. Andrews LF. The six keys to normal occlusion. Am J Orthod 1972;62:296-309.
16. Salmória I, Furtado A, Rosário HD, Furtado GC, Paranhos LR. Arnett

and Bergman facial analysis compared with aesthetic perception by lay people and dentists (general ractitioners and orthodontists). Biosci J 2014;30:297-303.
17. Ricketts RM, Bench RW, Hilgers JJ, Schulhof R. An overview of computerized cephalometrics. Am J Orthod 1972;61:1-28.
18. Houston WJ. The analysis of errors in orthodontic measurements. Am J Orthod 1983;83:382-90.
19. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159-74.
20. Tweed CH. The Frankfort-mandibular plane angle in orthodontic diagnosis, classification, treatment planning, and prognosis. Am J Orthod Oral Surg 1946;32:175-230.
21. Downs WB. Variations in facial relationships; their significance in treatment and prognosis. Am J Orthod 1948;34:812-40.
22. Riedel RA. The relation of maxillary structures to cranium in malocclusion and in normal oclusion. Angle Orthod 1952;22:142-5.
23. Steiner CC. Cephalometrics for you and me. Am J Orthod 1953;39:729-55.
24. Jarabak Jr, Fizzell JA. Technique and Treatment with Light Wire and Edge Wise Appliances. 2nd ed. St. Louis: Mosby; 1972.
25. Broadbent BH. A new X-ray technique and its application to orthodontia. Angle Orthod 1931;1:209-33.
26. Ricketts RM, Roth RH, Chaconas SJ, Schulhof RJ, Engle GA. Orthodontic Diagnosis and Planning. USA:Rocky Mountain Data Systems [S.I]; 1982.
27. Hasanreisoglu U, Berksun S, Aras K, Arslan I. An analysis of maxillary anterior teeth: Facial and dental proportions. J Prosthet Dent 2005;94:530-8.
28. Williams JL. The temperamental selection of artificial teeth, a fallacy. Dent Digest 1914;20:63-75.
29. Costalos PA, Sarraf K, Cangialosi TJ, Efstratiadis S. Evaluation of the accuracy of digital model analysis for the American Board of Orthodontics objective grading system for dental casts. Am J Orthod Dentofacial Orthop 2005;128:624-9.
30. Quimby ML, Vig KW, Rashid RG, Firestone AR. The accuracy and reliability of measurements made on computer-based digital models. Angle Orthod 2004;74:298-303.
31. El-Zanaty HM, El-Beialy AR, Abou El-Ezz AM, Attia KH, El-Bialy AR, Mostafa YA. Three-dimensional dental measurements: An alternative to plaster models. Am J Orthod Dentofacial Orthop 2010;137:259-65.
32. Koralakunte PR, Budihal DH. A clinical study to evaluate the correlation between maxillary central incisor tooth form and face form in an Indian population. J Oral Sci 2012;54:273-8.

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