Interalar Distance to Estimate the Combined Width of the Six Maxillary Anterior Teeth in Oral Rehabilitation Treatment

VANDERLEI LUIZ GOMES, DMD*
LUIZ CARLOS GONÇALVES, DMD*
MARCIO MAGNO COSTA, DMD*
BARBARA DE LIMA LUCAS, DDS†

ABSTRACT

Statement of the Problem: The face's architecture of dentate subjects has been studied to find a reliable guide for the selection of artificial anterior teeth. However, there is no consensus of data regarding a reference to estimate the width of artificial teeth.

Purpose: The purpose of this study was to analyze whether there is a consistent relationship between the interalar distance (IAD) and the combined mesiodistal width of the six maxillary anterior teeth.

Methods: Standardized digital photographs of 81 dentate Brazilian subjects were included in the sample. They were 37 men and 44 women (age 17 to 33). Through image processing software, the IAD and the distance between the tips of the maxillary canines were measured when viewed from the frontal aspect. Accurate casts were made to quantify the distance between the distal surfaces of the maxillary canines on a curve, by use of a flexible millimeter ruler. Nonparametric statistics were performed to analyze the results ($p < 0.05$).

Results: The IAD when compared with the width of the six maxillary anterior teeth, on a straight line and on a curve, presented a ratio of 0.914 and of 1.305, respectively. The Wilcoxon test showed no significant difference between the calculated width values and the mesiodistal width measured on a curve and on a straight line ($p = 0.986$).

Conclusion: The IAD, when increased by 31% of its value, can suggest the circumferential distance of the six maxillary anterior teeth.

CLINICAL SIGNIFICANCE

The width of the nose, when measured in digital photographs, can be utilized as a reliable guide for the selection of the maxillary anterior teeth width. It can improve the esthetic result of the oral rehabilitation treatment for the edentulous patient by offering a natural dentofacial relation.

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*Professor, Department of Removable Prosthodontics and Dental Materials, Faculty of Dentistry, Federal University of Uberlandia, Uberlandia, Minas Gerais, Brazil
†Postgraduate student, Faculty of Dentistry, Federal University of Uberlandia, Uberlandia, Minas Gerais, Brazil

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INTRODUCTION

Patients requiring complete dentures usually expect comfort first, followed by harmonious appearance, and last, efficiency.[1] The esthetic restoration of the edentulous patient has an important psychological effect. Once properly restored, patient self-esteem and self-confidence are often improved, which is also the goal of the oral rehabilitation treatment.[2–4]

Patients receiving their first dentures often expect to appear similar to when they had their natural teeth. Therefore, the correct selection of the artificial teeth is essential to achieving a pleasant esthetic outcome. If some natural teeth remain, it is easier to choose artificial teeth that blend with the natural dentition than to choose teeth for the edentulous patient with no pre-extraction records available.[1,3–5]

The art of tooth selection has changed over the last several decades due to a greater number of pamphlets, tooth guides, and folders made by tooth manufacturers to facilitate the selection process.[2,6] The mesiodistal width is a harder aspect to estimate than the proper height of the anterior artificial teeth.[4–9] The artificial tooth selection process can become difficult when the patient requests the reproduction of some details of the natural teeth—for instance, pigmentations, tooth irregularities, or physiologic wear. As a result, many professionals tend to pass this responsibility on to dental laboratory technicians who are quite limited by the fact that the technician only has casts and interocclusal records for guidance.

According to dentogenic restorations,[2] the shape and color of the teeth must be in harmony with the personality of the patient and his age attributes. In earlier studies, the relationship between the width of the nose and the mesiodistal width of the maxillary anterior teeth was investigated in dentate subjects, searching for a ratio between facial and dental dimensions.[5–7,10–13]

Kern[6] made measurements on 509 dried skulls and found that most nasal width measurements (93%) were equal to or within 0.5 mm of the width of the four maxillary incisors. In another study in which the nasal width was measured on soft tissue, there was no relationship between this facial structure and the total width of the four maxillary incisors, but the facial measurement seemed to be correlated with the distance between the tips of the maxillary canines.[11] Hasanreisoglu and colleagues[7] found no significant difference between the interalar width (IAW) and the distance between distal surfaces of the maxillary canines in females. However, there was a significant difference between those structures when they analyzed males.

Hoffman and colleagues[5] studied 340 North American subjects to investigate if the IAW could be used as a reliable guide for the selection of suitable anterior teeth when constructing dentures. The authors found that the mean of the distance between the tips of the maxillary canines was 3% bigger than the mean of IAW and that the mean of the distance between the distal surfaces of the maxillary canines was 31% bigger than the mean of the IAW.

The last several decades have seen significant development of new technologies in dentistry. The number of computer-based devices and functions in the dental office has increased, resulting in an ample and complex set of data that is the basis for further clinical decision making. Digital technologies have become mainstream in the dental practice, and digital imaging offers several advantages when applied in dentistry. This technology is important for diagnosis, virtual documentation, and photogrammetry, including the fact that photographs provide a permanent record of the patient on which an indefinite number of

measurements may be made at the investigator's leisure.

One of the most confusing aspects of the complete denture prosthodontics is the selection of appropriately sized maxillary anterior denture. There is no consensus of data regarding a single esthetic factor that can be used reliably as an aid for artificial tooth selection. During the denture construction, the length of the upper lip at rest and the smile design can be a reliable guide to estimate the height of the maxillary anterior teeth; however, no reliable anatomic parameters are available to select the adequate width of these teeth.[4–9] The purpose of this study was to compare the width of the maxillary anterior teeth with the interalar distance (IAD), measured in digital photographs, to verify the existence of consistent relationships between these measurements.

MATERIALS AND METHODS

Ethical approval was obtained from the local Committee on Research Ethics. A total of 81 dentate Brazilian subjects (37 men and 44 women) from the Federal University of Uberlandia, Brazil, were analyzed in this study. All subjects answered a questionnaire to investigate the dental arch conditions. The inclusion criteria considered the presence of facial median line matching with dental median line and Angle class I normal occlusion. The exclusion criteria included subjects who presented tooth agenesis, severe attrition, diastemas, or malocclusions, such as crowding teeth, overjet, overbite, and crossbites. Also, subjects who presented a history of facial surgery, or congenital facial anomalies, as well as tooth extraction, large restorations, or artificial crowns were excluded from this study.

Two standardized digital photographs of the face, generated from a frontal aspect, were made using a digital camera. An image processing software (HL IMAGE ++97, Western Vision Software; L.C, East Layton, UT, USA) was used to measure the apparent distance between the tips of the maxillary canines (TTP) and the IAD. The IAD was measured between the outer points of the ala of the nose in a straight line, corresponding to the morphological width of the nose.[14,15]

During the capture of the first photo (Figure 1), the volunteer was asked to sit and look forward to the horizon line. The method used to achieve the vertical dimension of rest position[16] was the instruction of relaxing the lower jaw and lightly touch the lips together, in a comfortable posture. The volunteers remained in a state of minimal tonic contracture sufficient only to maintain the posture. For the second photo, the student was asked to smile (Figure 2), thereby revealing the maxillary anterior teeth, allowing for the measurement of the distance between the tips of the maxillary canines in a straight line (TTP).

The photographic images were made by just one trained photographer. A distance of 56.0 cm between the digital camera lens and the tip of the subject's nose was established by the use of a top cord (top cord 3 m, L510CME; Lufkin, Kerrville, TX, USA). The digital camera was positioned on a tripod (VT40 Tron, 013002; Manaus, Amazonia, Brazil), which was 112.0 cm in height. The subject was instructed to position his or her face at a Wavrin modified set square, (Wavrin Trutype Tooth Guide; Dentist's Supply Co., New York, NY, USA), which standardized the head position and provided a measurable relationship between the image and the actual dimension.[17,18]

In addition to measuring the apparent mesiodistal width of the teeth, through an image measurement program, dense silicone (Silon2 APS; Dentsply, Petropolis, Rio de Janeiro, Brazil) was manipulated according to the manufacturer's instruction and was impressed onto the buccal surfaces of both the mandibular and

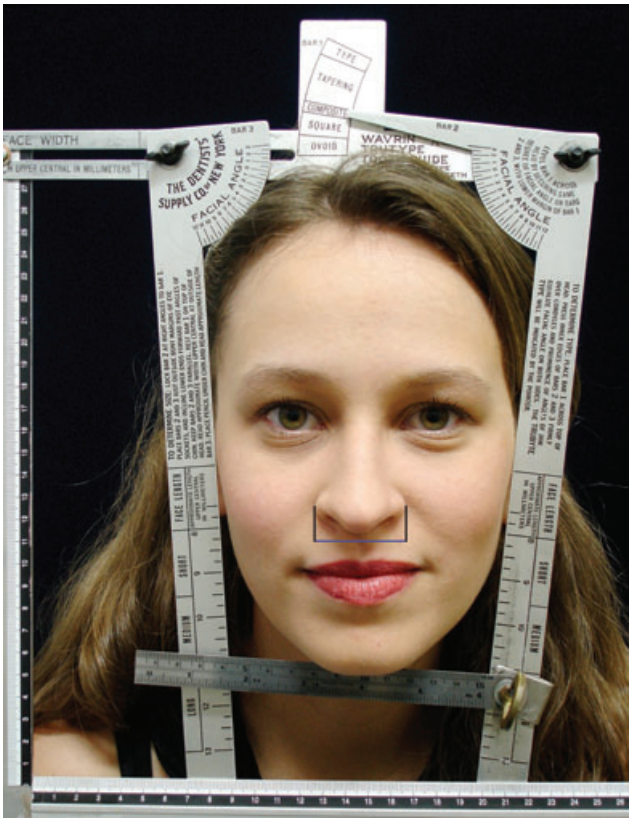

Figure 1. To measure interalar width (in blue).

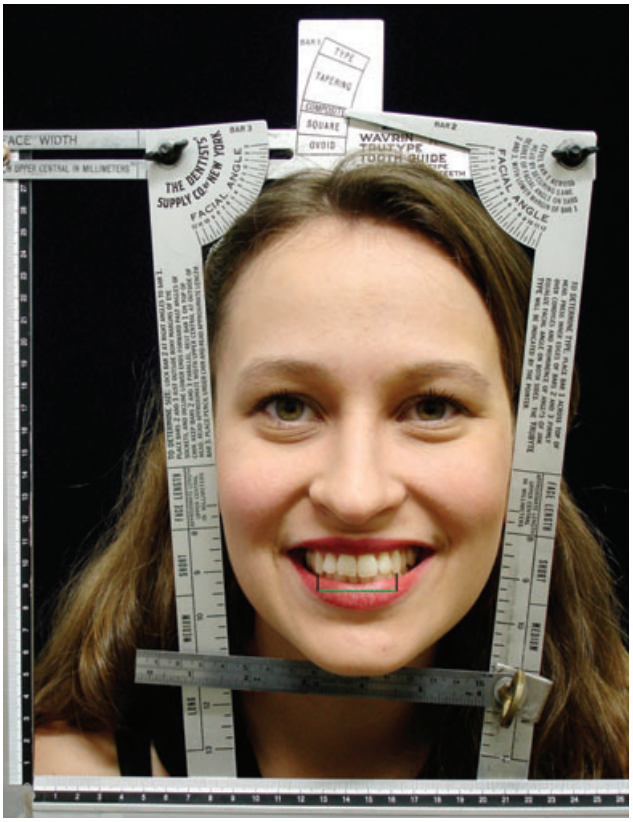

Figure 2. To measure distance between tips of maxillary canines (in green).

maxillary dental arches. Then, casts were constructed from hard plaster (Empresa e Indústria Gesso Mossoró SA, Rio de Janeiro, RJ, Brazil) that extended from the first maxillary left premolar to the first maxillary right premolar. These casts were used to measure the mesiodistal width on a curve when placed on the dental arch (Figure 3). A flexible millimeter ruler was used to measure the distance between distal surfaces of the maxillary canines on a curve (DDC) from the region of the proximal contact points.[17]

For the sake of consistency, the same examiner made all the records and performed all of the measurements three times, on different days and times. From the three results, a mean value was calculated to establish the consistency of the measurements and the reliability of the evaluator. Based on the evidence that the sample distribution was not normal and that the sample available for the analysis was less than 100 observations, nonparametric statistical tests were conducted. The data were analyzed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA). Results that were significant at the $p < 0.05$ level were considered statistically significant.

RESULTS

The volunteers ranged from 17 to 33 years of age, with a mean of 21 years. For each recorded measurement (IAD, TTP, and DDC), Tables 1 and 2 present the median values and SD for the total sample. Figure 4 illustrates the median values for the total sample, and for the sample divided according to

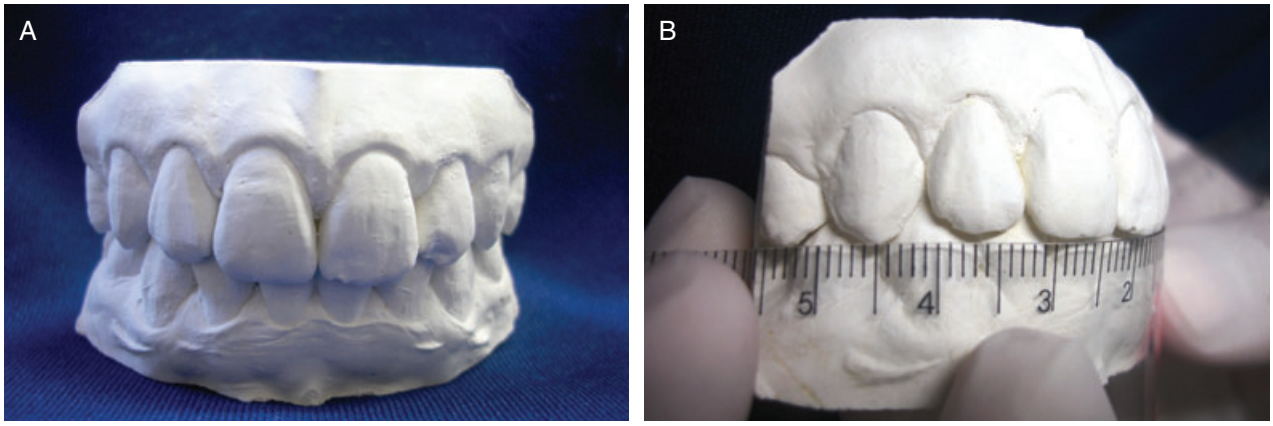

Figure 3. A, *Front-view of cast.* B, *Flexible millimeter ruler to measure, on curve, distance between distal surfaces of maxillary canines.*

TABLE 1. MEDIAN VALUES (IN MILLIMETERS) AND SD FOR ALL FACIAL AND DENTAL SEGMENTS.

Segments	Median	SD
IAD	41.220	(3.515)
TTP	37.440	(2.334)
DDC	53.670	(3.324)

DDC = distance between distal surfaces of maxillary canines, measured on cast; IAD = interalar distance, measured in digital photographs; TTP = distance between tips of maxillary canines, measured in digital photographs.

TABLE 2. MEDIAN VALUES (IN MILLIMETERS), SD, AND PROBABILITIES FOUND BY MANN–WHITNEY *U*-TEST, FOR ALL FACIAL AND DENTAL SEGMENTS WHEN THE SAMPLE WAS DIVIDED ACCORDING TO GENDER ($p < 0.05$).

Segments	Female	Male	Probabilities
IAD	38.785 (3.118)	43.190 (2.644)	0.000
TTP	37.050 (2.124)	38.010 (2.402)	0.068
DDC	53.500 (3.282)	54.000 (3.250)	0.033

DDC = distance between distal surfaces of maxillary canines, measured on cast; IAD = interalar distance, measured in digital photographs; TTP = distance between tips of maxillary canines, measured in digital photographs.

gender. The Mann–Whitney *U*-test was used to verify specific differences according to gender ($p < 0.05$). A statistically significant difference ($p = 0.000$) was found relative to gender regarding the size of the nose (IAD) and the combined widths of the maxillary anterior teeth (TTP) measured on the picture ($p = 0.033$). For these two measurements, the values found for males were bigger than those found for females. However, there were no significant differences relative to gender for the combined widths of the maxillary teeth (DDC) measured on the cast ($p = 0.068$). Table 2 presents the Mann–Whitney *U*-test results and the median values for the sample divided according to gender.

After comparing the IAD mean value with both TTP and DDC

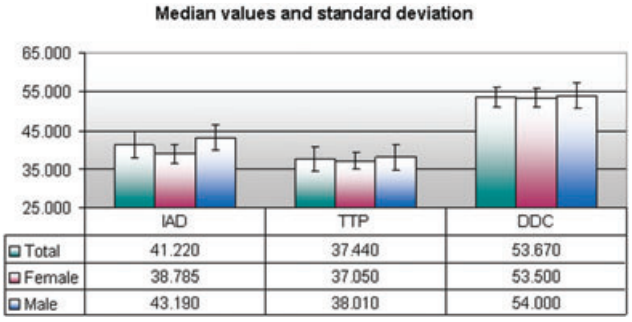

Figure 4. Median values (in millimeters) and SD for all facial and dental segments for total sample, and for sample divided according to gender.

mean values, a ratio of 1.305 between IAD and DDC was found (Table 3). The IAD value was increased by 30.5% of its value for each subject. These calculated values for IAD were compared with the real values of the DDC. Also, a ratio of 0.914 between IAD and TTP was found (Table 3), and the IAD value was decreased by 8.6% of its value for each subject, and the results compared with the real values for the TTP. The Wilcoxon signed-rank test was used to test different scores between actual and calculated mesiodistal values: the DDC actual values and the DDC calculated values (from the IAD multiplied by 1.305), as well as the TTP actual values and the TTP calculated values (from the IAD multiplied by 0.914). As shown in Table 4, there were no significant differences between the actual and the calculated mesiodistal width values.

DISCUSSION

The distance between the tips of maxillary canines measured in digital photographs (TTP) showed a median of 37.44 mm, ranging from 31.58 to 43.35 mm. Hoffman and colleagues[5] also measured the distance between the tips of the maxillary canines in a straight line but used a Boley gauge situated on a wax registration. The authors[5] found a mean of 35.35 mm, and a range from 30.00 to 46.00 mm. A mean of 34.30 mm was published by Mavroskoufis and colleagues[11] who recorded the intercanine distance with dividers to an accuracy of 0.1 mm.

The distance between the distal surfaces on the cast (DDC) presented a median of 53.67 mm and values between 45.00 and 60.33 mm. This value was similar to the mean value of 53.70 mm published by McArthur[9] who measured the circumferential distance on cast with a flexible millimeter ruler and found a range from 47.00 to 63.00 mm. Hoffman and colleagues[5] found a mean value of 44.85 mm to the circumferential arch distance between the distal surfaces and a range from 35.00 to 61.00 mm.

Significant variation for the measurements of the IAW is present in data. This fact may be due to either the methodology used to measure this facial segment or the ethnic differences of the studied population. It is a consensus of data that genetic heritage is the main cause for the similarities found between North American white individuals and European white individuals and for varieties found between different ethnic groups.[9,11,14,15,18,19] Unproven theories suggest that in hot and moist climates the nasal aperture becomes much wider, present in all African and Asian ethnic groups in both genders, than in those individuals who live in cold places.[19]

As shown in Table 2, a significant difference was found in the Mann–Whitney *U*-test within the gender groups for the IAD. The IAW of the total sample showed a median of 41.22 mm, ranging from 32.93 to 48.31 mm. Latta and colleagues[13] found a mean of 43.93 mm in edentulous patients from North America, ranging from 29.00 to 63.00 mm, after measuring facial structures with a Boley

TABLE 3. RATIOS FOUND AFTER THE DIVISION OF TTP BY IAD VALUE AND DDC BY IAD VALUE.

Comparison	Ratio
TTP to IAD	0.914
DDC to IAD	1.305

DDC = distance between distal surfaces of maxillary canines, measured on cast; IAD = interalar distance, measured in digital photographs; TTP = distance between tips of maxillary canines, measured in digital photographs.

TABLE 4. WILCOXON SIGNED-RANK TEST RESULTS FOR THE COMPARISON BETWEEN ACTUAL WIDTH VALUES AND CALCULATED WIDTH VALUES FOR MAXILLARY ANTERIOR TEETH: IAD × 0.914—CALCULATED VALUE FOR TTP; IAD × 1.305—CALCULATED VALUE FOR DDC ($p < 0.05$).

Comparison	Probabilities
TTP to (IAD × 0.914)	0.986
DDC to (IAD × 1.305)	0.986

DDC = distance between distal surfaces of maxillary canines, measured on cast; IAD = interalar distance, measured in digital photographs; TTP = distance between tips of maxillary canines, measured in digital photographs.

gauge. Leong and colleagues[14] found a mean of 36.00 mm after analyzing facial photographs in 50 Caucasians. In an earlier study,[15] they compared the nose width in the Asian and Caucasian groups and found a mean of 41.00 mm for Asian males, 37.00 mm for Caucasian males, 38.00 mm for Asian females, and 34.00 mm for Caucasian females. Fariaby and colleagues[18] reported a mean of 37.00 mm with a range from 26.00 to 45.00 mm with a significant difference according to gender (39.00 mm for males and 35.00 mm for females from Iran). Mavroskoufis and colleagues[11] found a mean of 35.30 mm after recording the IAW with a Willis gauge in 64 white subjects.

Farkas and colleagues[19] studied anthropometric measurements of different ethnic groups and compared them with the measurements of North American white subjects. The morphological width of the nose showed the following values: 34.70 mm for North American white men and 31.40 mm for North American white women, 36.60 mm for Portuguese men and 31.90 mm for Portuguese women, 40.80 mm for men from Thailand and 40.20 mm for women from Thailand, and 46.30 mm for Angolan males and 40.80 mm for Angolan females.

Hoffman and colleagues[5] measured the IAW in soft tissue, with a Boley gauge, and published a mean of 34.28 mm, with minimum and maximum values of 26.90 mm and 50.00 mm, respectively. After comparing the IAW mean values with the mesiodistal width mean values of the maxillary anterior teeth, both in a straight line and on a curve, they found ratios of 1.03 and 1.31, in that order. Therefore, when the IAW was multiplied by a factor of 1.03 or increased by 3% in its value, it could approximate the mesiodistal width value of the maxillary anterior teeth in a straight line, measured between the tips of the canines. Also, when the IAW was multiplied by a factor of 1.31 or when it was increased by 31% in its value, it could estimate the mesiodistal width value of the maxillary anterior teeth on a curve.

The same analysis was carried out in this study. Table 3 presents the ratios found for both comparisons. The ratios were applied to the IAD values in order to produce calculated teeth values. These calculated

values were then compared with the actual values by use of Wilcoxon signed-rank test. The test results showed no significant differences between the actual and calculated mesiodistal width tooth values for both comparisons.

Thus, when the maxillary teeth are measured in a straight line between the tips of the canines, by use of digital image of the face, the value obtained should equal the IAD reduced by 8.6% of its value ($p = 0.986$). Also, the value of the mesiodistal width of the maxillary anterior teeth measured on a curve should equal the IAD increased by 30.5% in its value ($p = 0.986$). These results can be observed in Table 4.

After measuring the IAW through radiography, Smith,[10] found no significant difference between intercanine distance and IAW. It is known that the values obtained by direct anthropometry (using measuring instruments) are close to those obtained by indirect anthropometry (photogrammetry)[20,21] and far from those obtained by radiographic method.[22] Although the landmarks are clearly visible on the radiographs, two-dimensional radiographic film is likely to exhibit distorted and unreliable findings.[23] So this could illustrate how differences in the methodology applied can influence the final results.

Despite the factor of 3% published by Hoffman and colleagues[5] to estimate the distance between the maxillary canines (TTP), in this study a factor of 8.6% of IAD reduction was found rather than of IAD increase. This divergence can also be due to the differences in methodology. Hoffman and colleagues[5] measured the TTP by use of a wax registration and a Boley gauge, whereas digital images were used in this study.

Farkas and colleagues[19] published different IAD values for groups of Asian, African, and Caucasian individuals, with bigger values corresponding to those of African and Asian groups. In this study, the IAD presented a median of 40.970 mm, whereas for Hoffman and colleagues[5] it was 34.280 mm. Despite the different nose width, the ratio of 1.31 found by Hoffman and colleagues[5] can be used to estimate the DDC from the values of IAD in this sample (Table 4). Therefore, the IAD seems to be a reliable guide to estimate the mesiodistal width of the artificial anterior teeth for edentulous patients.

The teeth, as with the other perspectives of dental esthetics, display variance and nuances, showing individuality in a given dentition. For this reason, when restoring or replacing the teeth, dental professionals should also consider useful fundamental guidelines for creating a pleasing esthetic result. The adequate width : length ratio of the maxillary anterior teeth should be present, and the central incisor should be the dominant element in the anterior dental composition. In addition, lateral incisors and canines should be positioned to offer a display in successive decreasing widths. Individual cultural characteristics and perceptions of beauty must be considered. Besides these principles, subtle variations can be introduced that account for gender, race, facial, morphopsychological, and psychological factors.[24]

CONCLUSIONS

One of the most confusing aspects of the complete denture prosthodontics is the selection of appropriately sized maxillary anterior teeth. There is no consensus of data regarding a single esthetic factor that can be used reliably as an aid for artificial tooth selection. New technologies have been introduced in dentistry during the last decades. Digital imaging has become a mainstream in the dental practice, and advances in computer technology have provided the dental professional with new tools that allow digitizing, measuring, displaying, and manipulating facial images.

This article has tried to innovate and improve the selection of the

combined width of maxillary anterior teeth by adding digital imaging and linear analysis of the soft tissue. The IAD, measured through photogrammetry, was compared with the combined width of the maxillary anterior teeth to verify whether consistent relationships exist in a subset of the Brazilian population.

A ratio of 0.914 between the tips of the maxillary canines (TTP) and the IAD was found for the population considered. This factor when applied to the nose width decreases in 8.6% of its value. Also, a ratio of 1.31 was presented when the circumferential distance between the distal surfaces of the maxillary canines (DDC) was compared with the IAD. This ratio can be used to estimate the combined width of the maxillary artificial teeth selected for Brazilian people. The adequate selection of each maxillary anterior tooth width could also offer variance and individuality to the denture. However, other studies are necessary to evaluate the individual selection of the acceptable size of each tooth of the anterior dental segment.

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Reprint requests: Vanderlei Luiz Gomes, DMD, Av. Pará n°1720, Umuarama Camp, Bloco 2B, Sl 07/08, Uberlandia, MG 38401-136, Brazil; Fax: +5534-3218-2626; email: vanderlei@ufu.br