# Correlation between the Individual and the Combined Width of the Six Maxillary Anterior Teeth

LUIZ CARLOS GONÇALVES, DMD\* VANDERLEI LUIZ GOMES, DMD\* BARBARA DE LIMA LUCAS, DDS<sup>†</sup> SILAS BORGES MONTEIRO, DDS<sup>‡</sup>

## ABSTRACT

*Purpose:* There is a consensus in the community of dental research that the selection of undersized artificial maxillary anterior teeth offers an unnatural appearance to the denture. Several methods to select the adequate width of these teeth are of questionable validity, and many dentures have an obviously artificial appearance. This article assessed the relationship between the individual and the combined width of maxillary anterior teeth.

*Materials and Methods:* Impressions were made of the anterior dentition of 69 dentate undergraduate students with rubber impression silicon, and casts were formed. The individual widths of the maxillary anterior teeth were measured by using a digital caliper (SC-6 digital caliper, Mitutoyo Corporation, Tokyo, Japan), and the combined width was registered by both adding the individual width and using a flexible millimeter ruler.

*Results:* Student's *t*-test showed significant differences between the analogous teeth and different sides of the maxillary dental arch (p = 0.001), with the exception of the central incisor (p = 0.984). Pearson's product moment correlation coefficient showed significant positive correlation between all the measurements compared (p = 0.000). Linear regression analysis concluded three mathematical equations to obtain the individual tooth width after measuring the combined width of the six maxillary anterior teeth by using a flexible millimeter ruler.

*Conclusions:* The individual tooth width can be determined if the combined width of the maxillary anterior teeth is obtained by using a flexible millimeter ruler.

## CLINICAL SIGNIFICANCE

The adequate selection of each maxillary anterior tooth width can offer variance and individuality to the denture, particularly for partially dentate patients. By offering an adequate toothto-tooth relationship, the esthetic result of the oral rehabilitation treatment can be improved.

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\*Professor, Department of Removable Prosthodontics and Dental Materials, Faculty of Dentistry, Federal University of Uberlandia, Uberlandia, Minas Gerais, Brazil <sup>†</sup>Postgraduate student, Faculty of Dentistry, Federal University of Uberlandia, Uberlandia, Minas Gerais, Brazil <sup>‡</sup>Intern, Department of Removable Prosthodontics and Dental Materials, Faculty of Dentistry, Federal University of Uberlandia, Uberlandia, Minas Gerais, Brazil

#### INTRODUCTION

The search for the adequate tooth arrangement, which improves denture stability, comfort, esthetics, and function, has been discussed in the dental literature for many years. Many anatomic landmarks have been used as guides when there are no preextraction records such as photographs or dental casts.<sup>1-14</sup> Most of these studies considered anterior tooth arrangement because they are the most visible in the dental arch when viewed from the frontal aspect.

The ideal tooth positioning, which relates the successive widths of the anterior teeth, plays an important role in facial esthetics and, consequently, guarantees the satisfaction of the patient and the excellent outcome of the oral rehabilitation treatment.<sup>11,12</sup> Any prosthetic treatment, removable or fixed, that involves the replacement of the natural teeth is considered to be rather critical.<sup>15</sup> In this case, the outcome of the esthetic factor depends on the adequate lip-tooth relationship. The lips must guarantee, either at rest or during function, sufficient soft-tissue support and balanced smile design.<sup>16</sup>

Usually, prostheses replacing anterior teeth frequently look artificial because the teeth that have been selected are smaller than the natural teeth.<sup>9,17–19</sup> The mesiodistal width is a harder aspect to estimate than the proper height of the anterior artificial teeth for removable prostheses.<sup>18–20</sup> The height of anterior teeth can be selected according to the length of the upper lip at rest and the smile design in order to avoid showing the denture base.

For partially dentate patients, who present limited maxillary anterior space, the width of the artificial teeth must perfectly fit into the limited space, blend with the natural dentition, and offer both ideal tooth positioning with successive widths and adequate lip-tooth relationship. In this case, the replacement of the anterior teeth is a relatively complex procedure.

There is no universally accepted method to guarantee an adequate tooth-to-tooth relationship that can be used reliably to aid artificial tooth selection, particularly for partially dentate patients.<sup>12,20–23</sup> For this reason, this study verified if there is a significant correlation between the individual width of each maxillary anterior tooth and the distance between the distal surfaces of maxillary canines.

### METHODS

Undergraduate students from the Federal University of Uberlandia

were invited to participate in this study. They signed the informed consent and answered a questionnaire that evaluated their dental conditions. The inclusion criteria considered the presence of facial median line matching with dental median line and occlusion Class I of Angle. The exclusion criteria involved subjects who presented tooth agenesis, severe attrition, diastemas, or malocclusions such as crowding teeth, overjet, overbite, and cross-bites. Also, subjects who presented a dental history of tooth extraction, large restorations, or artificial crowns were excluded from this study. Orthodontically, treated individuals were not excluded from this analysis because they represent the best sample to measure the tooth width.18,19

Dense silicone was manipulated according to the instructions of the manufacturer (Silon2 APS, Dentsply Ind e Comercio Ltda, Petropolis, Rio de Janeiro, Brazil) and impressed onto the buccal surfaces of both the mandibular and maxillary dental arches. Casts were fabricated from type IV dental stone (Tuff Rock, Talladium do Brasil, Produtos Prótese Dentária Ltda, Curitiba, Paraná, Brazil) that extended from the first maxillary and mandibular left premolar to the first maxillary and mandibular right premolar (Figure 1).



Figure 1. Front-view of a cast.



Figure 2. Digital caliper to measure individual width of six maxillary anterior teeth.

The individual widths of the maxillary anterior teeth were measured by using a digital caliper (SC-6 digital caliper, Mitutoyo Corporation, Tokyo, Japan) placed on the region of the proximal contact points, as shown in Figure 2. All maxillary teeth were measured: right canine (RC), right lateral incisor (RLI), right lateral incisor (RCI), left central incisor (LCI), left lateral incisor (LLI), and left canine (LC). The combined width of the six maxillary anterior teeth, obtained by the digital caliper, was calculated by summing all the individual widths. Also, the combined width of the maxillary anterior teeth was measured by using a flexible millimeter ruler, positioned on the region of the proximal contact points (Figure 3).<sup>9,18,19</sup>

One trained and calibrated examiner made all measurements on different days and times. Three measurements were taken for each dimension observed, and Pearson's correlation was used to evaluate the intraexaminer reliability. A mean was calculated to exclude the possibility of unreliable numbers.<sup>24</sup> The data were organized, and the normal sample distribution was confirmed by the Kurtosis test. Parametrical statistics were performed (p < 0.05) by using SPSS software (SPSS Inc., Chicago, IL, USA).

#### RESULTS

Sixty-nine undergraduate students (28 male) from the Federal University of Uberlandia participated in this study. They were between 17 and 33 years of age with a mean age of 21 years. Figure 4 presents mean values and standard deviations for each individual tooth width measured with the digital caliper. Student's *t*-test verified if there was a significant difference between analogous teeth from both sides of the dental arch (RCI and LCI, RLI and LLI, RC and LC). Significant differences were found between all comparisons, with the exception of the central incisor. When the sample was grouped according to gender, the same result was found for females, whereas, in males, only the lateral incisor presented significant differences between both sides of the dental arch (Table 1).

Student's *t*-test verified significant differences between genders for each individual tooth width (Table 2). The results demonstrate that, between gender, there were marked differences in size of the maxillary anterior teeth, with the exception of the RLI (p = 0.631) and LLI (p = 0.816).





Figure 3. A flexible millimeter ruler to measure, on curve, distance between distal surfaces of maxillary canines.

Figure 4. Values in millimeters (mm) for the individual tooth widths. Mean values and standard deviation (SD) for each maxillary anterior tooth: right canine (RC), right lateral incisor (RLI), right central incisor (RCI), left central incisor (LCI), left lateral incisor (LLI), and left canine (LC).

## TABLE 1. PROBABILITIES (p) FOUND AFTER THE APPLICATION OF STUDENT 7-TEST FOR DIFFERENCES BETWEEN ANALOGOUS TEETH AND DIFFERENT SIDES OF DENTAL ARCH.

p Value			
Total	Female	Male	
0.984	0.179	0.102	
0.002	0.021	0.047	
0.004	0.007	0.179	
	<b>Total</b> 0.984 0.002 0.004	p Value   Total Female   0.984 0.179   0.002 0.021   0.004 0.007	

LC = left canine; LCI = left central incisor; LLI = left lateral incisor; RC = right canine; RCI = right central incisor; RLI = right lateral incisor.

Figure 5 illustrates the mean values and standard deviations for the combined width of the maxillary anterior teeth, measured by both the digital caliper and the flexible millimeter ruler. The size of both analogous anterior teeth in relation to the total width of the maxillary anterior teeth is available in Table 3 for both measuring instruments. A mean of the width of the analogous teeth from different sides of the dental arch was calculated, resulting in three teeth widths instead of six. Figures 6 and 7 illustrate, in percentages, the size of the analogous anterior teeth width in relation to the total width of the maxillary anterior teeth, respectively, when the flexible ruler and the caliper were used.

Pearson's product moment correlation coefficient tested if the combined widths of the maxillary teeth, measured by both instruments, were correlated to the individual width of maxillary anterior teeth ( $\alpha = 0.05$ ). Table 4 shows significant positive correlations between all the measurements compared (p = 0.000).

After finding significant correlations between the comparisons, linear regression analysis was used to conclude three mathematical equations to estimate the individual tooth width from the combined width of the six maxillary anterior teeth, measured by using a flexible millimeter ruler (Figures 8–10).

## DISCUSSION

The Brazilian population is one of the most heterogeneous in the world because of the mixture of Amerindians, Europeans, Africans, and, recently, Asians.<sup>25,26</sup> Nowadays, as a result of five centuries of interethnic crosses between peoples from three continents, there is an enormous ethnically and culturally

TABLE 2. PROBABILITIES ( <i>p</i> ) FOUND AFTER THE APPLICATION OF STUDENT <i>T</i> -TEST FOR DIFFERENCES BETWEEN TEETH WIDTH AND DIFFERENT GENDERS.				
Comparisons	p			
RC	0.035			
RLI	0.631			
RCI	0.020			
LCI	0.001			
LLI	0.816			
IC	0.012			

LC = left canine; LCI = left central incisor; LLI = left lateral incisor; RC = right canine; RCI = right central incisor; RLI = right lateral incisor.

#### TABLE 3. MEAN VALUES, IN PERCENTAGES, FOR INDIVIDUAL WIDTH OF ANTERIOR TEETH TO THE TOTAL WIDTH OF MAXILLARY ANTERIOR TEETH, MEASURED BY BOTH MEASURING INSTRUMENTS: FLEXIBLE MILLIMETER RULER AND DIGITAL CALIPER.

Maxillary teeth	Flexible ruler	Digital caliper
Canines	15.26	16.65
Lateral incisors	13.35	14.57
Central incisors	17.28	18.85



**Measuring Instrument** 

Figure 5. Values in millimeters (mm) for the combined width of the anterior teeth. Mean values and standard deviation (SD) offered by both measuring instruments: flexible millimeter ruler and digital caliper.

complex society in Brazil, which makes their classification into pure ethnic groups inadequate. Surrounded by this reality, the sample of this study was not categorized according to its racial differences. However, the collected data are in agreement with other studies performed in different populations, which enables the researchers to compare the results. Any differences found in anthropometric studies similar to those of the present study can be a result of dissimilarities either in measuring instruments used to calculate parts of the human body or in the range of the age of the samples compared.

Several studies have investigated a reliable guide to select the individual tooth width and to proportionate the maxillary anterior teeth. However, up to now, no agreement in the dental literature has been presented to relate the successive widths of the anterior teeth.<sup>12,20-23</sup> When considering simply functional and esthetic aspects, the lack of just the six maxillary anterior teeth suggests more complexity to the dental treatment.<sup>18-20</sup>

During the rehabilitation of the maxillary anterior dental segment, dental professionals have the following references: the distance between the distal surfaces of the maxillary canines, which can be measured by a flexible millimeter ruler, and the width of the artificial dental replacements offered by the artificial teeth manufacturer. After each individual width of natural teeth was measured, in healthy dentate individuals, the size that each tooth occupies in the anterior dental segment was calculated in percentages (Table 3). The width of



Figure 6. Values in percentages for both analogous anterior teeth to the total width of maxillary anterior teeth measured with flexible millimeter ruler.

Width of maxillary canines



Figure 8. Scattterplot to illustrate the relationship between combined width of six maxillary anterior teeth (x) and maxillary canines (y).



Figure 7. Values in percentages for both analogous anterior teeth to the total width of maxillary anterior teeth measured with digital caliper.



Figure 9. Scattterplot to illustrate the relationship between combined width of six maxillary anterior teeth (x) and maxillary lateral incisors (y).

TABLE 4. PEARSON'S PRODUCT MOMENT CORRELATION COEFFICIENT (r) AND ITS PROBABILITIES (p) RESULTED FROM THE ANALYSIS OF TOTAL SAMPLE ( $\alpha = 0.05$ ).							
Maxillary teeth	Digital caliper		Flexible ruler				
	r	р	r	р			
Canines	0.835	0.000	0.726	0.000			
Lateral incisors	0.835	0.000	0.746	0.000			
Central incisors	0 540	0.000	0 483	0.000			

both maxillary canines corresponds to 33% of the anterior dental segment, the width of both lateral incisors represents 29%, and the width of both central incisors represents 38% (Figures 6 and 7). These percentages can aid in identifying the individual width of each artificial maxillary anterior tooth while replacing the natural anterior teeth during the oral rehabilitation treatment. In this study, a mean of 8.71 mm was found for the RCI and the LCI, ranging between 7.27 and 10.15 mm, which is in agreement with the dental literature.<sup>6,12,15,17,19,20,27-30</sup> No significant differences were found for the central incisors of different sides of the dental arch, even when the sample was grouped according to gender (Table 1). This indicated that these teeth presented considerable symmetry when just the mesiodistal diameter was evaluated. However, as in the

## Width of maxillary lateral incisors



Figure 10. Scattterplot to illustrate the relationship between combined width of six maxillary anterior teeth (x) and maxillary central incisors (y).

literature,<sup>12,15,19,20</sup> the width of central incisors between individuals of both genders presented a significant difference: 8.97 mm for males and 8.53 mm for females.

The number of reports for the width of lateral incisors and canines is inferior to that of central incisors because of the magnitude of the central incisors in the maxillary anterior dental segment. The means 6.73 mm for the lateral incisors and 7.70 mm for the canines were found in this research. These values are in agreement with other studies.<sup>12,27,29-31</sup> As shown in Table 1, the lateral incisors of different sides of the dental arch showed significant differences in width (p = 0.002) even when the same evaluation was performed in the sample grouped by gender (p = 0.047 for males; and p = 0.021for females). In contrast, the maxillary canines are different in width only for the total sample and for

females (p = 0.004 and p = 0.007, respectively). Table 1 shows that it is only in males wherein the width of maxillary canines of both sides of the dental arch was not different (p = 0.179).

The width of the six maxillary anterior teeth, obtained by the sum of each individual tooth width, was compared with the results achieved by the flexible millimeter ruler. Significant differences were found between the values offered by both measuring instruments. The flexible millimeter ruler showed a mean of 50.420 mm and a range between 43.667 and 58.667 mm while summing each individual tooth width obtained by the caliper achieved a mean of 46.219 mm and values ranging from 40.833 to 52.733 mm. Al Wazzan<sup>15</sup> published a mean of 45.230 mm after summing each individual tooth width obtained by a Boley gauge positioned on the

teeth intraorally. This mean is in agreement with this study and with the research of Bernabé and colleagues<sup>32</sup> who found a mean of 48.86 mm.

The mean offered while utilizing a flexible ruler is close to 53.610 mm found by Scandrett and colleagues<sup>6</sup> and to 53.670 mm found by Gomes and colleagues.<sup>24</sup> McArthur<sup>19</sup> found a mean of 53.7 mm, ranging from 47.0 to 63.0 mm, with 54.6 mm for males and a mean of 52.3 mm in females as the biggest values. In the present study, regardless of the biggest values found for males (54.317 mm) when compared with the mean of 53.011 mm for females. Student's *t*-test showed no significant difference between genders (p = 0.206), which is similar to the findings of Gomes and colleagues.24

Significant positive correlations were found after comparing the size of analogous teeth with the combined width of the six maxillary anterior teeth obtained by both the flexible ruler and the digital caliper (Table 4). The absence of the maxillary anterior teeth makes the use of the digital caliper inappropriate. In these cases, the flexible millimeter ruler can be positioned on the wax record, to quantify the space available in a curve to arrange the anterior teeth. After a significant correlation between the combined and the individual width of the six maxillary anterior teeth was found, linear regression analysis was carried out, and three mathematical equations were concluded to relate both dimensions. The goal of linear regression procedures is to fit a line through the points. The regression line expresses the best prediction of the individual tooth width, which is the dependent variable (v), given the combined width of the maxillary anterior tooth, obtained by a flexible millimeter ruler, which is the independent variable (x).

However, nature is rarely perfectly predictable, and usually there is substantial variation in the observed points around the fitted regression line, as observed in the scatterplots (Figures 8-10). The deviation of a particular point from the regression line is called residual value. The smaller the variability in the residual values around the regression line relative to the overall variability, the better is the prediction. Those residual values could be reduced if the mathematical relation had been concluded for the sample grouped by gender as well as by different sides of the dental arch. This would have resulted in five mathematical equations for each gender.

Both correlation coefficients and probabilities found for the

comparisons were high. Therefore, these mathematical equations can be a reliable aid to estimate the individual tooth width after obtaining the width of the six maxillary anterior teeth with a flexible millimeter ruler. Other studies testing different populations are required to verify the application and the relevance of these equations.

During the construction of dentures, the selection of artificial teeth is based on three measurements offered by the manufacturers: the combined width of the anterior dental segment, and the width and the height of the central incisor. As a result, dental professionals nowadays are required to purchase the model of artificial teeth, which includes all six maxillary anterior teeth. The selection of each maxillary anterior tooth is still not available in the market, and some studies show that the artificial substitutes are not similar in size to the natural teeth.<sup>9,14,17,18</sup> These difficulties associated with the impossibility of acquiring artificial teeth independently result in dentures with artificial appearance as a result of the lack of variance and nuances that exist in the natural dentition. The manufacturers of artificial teeth could help to perform this requisite manufacturing model of two artificial teeth, such as grouping only the central

incisors, the lateral incisors, and the canines instead of grouping all six maxillary anterior teeth.

## CONCLUSION

One of the most confusing aspects of the complete denture prosthodontics is the selection of appropriately sized maxillary anterior denture. There is no universally accepted method to guarantee the adequate toothto-tooth relationship that can be used reliably to aid artificial tooth selection, particularly for partially dentate patients.12,20-23 For this reason, when restoring or replacing the natural teeth, dental professionals should also consider useful fundamental guidelines for creating a pleasing esthetic result. The maxillary central incisor should be the dominant element in the anterior dental composition, and both teeth should occupy 38% of the total anterior dental segment. The lateral incisors (29%) and canines (33%) should be positioned to offer a display in successive decreasing widths.

This article has tried to emphasize the necessity of selecting the artificial teeth separately to provide individuality in the denture. Significant correlations were found between the individual and the combined width of the six maxillary anterior teeth measured in dentate undergraduate students. After concluding three mathematical equations, the individual width of each maxillary anterior tooth can be estimated from the distance between the maxillary canines, measured by using a flexible millimeter ruler.

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