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CLINICAL SCIENCE

# Biometric analysis of the clinical crown and the width/length ratio in the maxillary anterior region

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## ABSTRACT

**Statement of problem.** Restorative dentistry often involves correcting tooth size discrepancies. Therefore, dental biometrics should play an important role in the planning of an esthetic restoration.

**Purpose.** The purpose of this study was to analyze the clinical crown width, length, and width/length ratio of maxillary central incisors, lateral incisors, and canines in an adult population. The study also aimed to determine whether a correlation exists between natural tooth dimensions and the optimal tooth dimension guidelines suggested for planning esthetic restorations.

**Material and methods.** Stone casts were poured from irreversible hydrocolloid impressions of 412 healthy adult participants. These casts were used to measure the maximum mesiodistal width and maximum crown-root length of the maxillary central incisors, lateral incisors, and canines with a digital precision caliper (0.01 mm). The width/length ratio was calculated for each tooth, and 40 casts were selected to test the reliability of the measuring method.

**Results.** The mean age of the participants in the sample was 33.94 years; 60.7% were women and 39.3% were men. The mean width value was 8.71 mm for central incisors, 6.75 mm for lateral incisors, and 7.81 mm for canines. The mean length was 10.23 mm for central incisors, 8.59 mm for lateral incisors, and 9.93 mm for canines. The average width/length ratio was 85% for central incisors and 79% for lateral incisors and canines.

**Conclusion.** The data obtained from the population studied are similar to those from previous research studies with similar methodology. However, great discrepancies in the absolute values were found when compared with other studies of ideal tooth dimension guidelines on the personal preferences and the esthetic perception of dentists. The perception of what is considered natural seems to differ from what is considered esthetically perfect. (J Prosthet Dent 2015;113:565-570)

The demand for an esthetic smile has increased in recent decades. Any dental treatment should aim to provide both a natural and esthetic appearance, especially in the fields of prosthodontics and restorative dentistry.[1,2] However, the patient's perception of dentofacial esthetics does not necessarily match the dentist's perception, which highlights the importance of establishing an esthetic diagnosis prior to treatment.[3-5]

Esthetic dentistry often involves correcting tooth size discrepancies either in length or width. As a result, dental biometrics is a key aspect of esthetic restorations. The proportion of each individual tooth within the maxillary anterior maxilla region is the percentage obtained by dividing its width by its length. Many authors have tried to establish a set figure for this proportion in order to facilitate the esthetic restoration of a smile.[6-9] The current interest in esthetics has led to the publishing of different guideline figures for restorative treatment, but the existence of several different guidelines is confusing when clinicians must select the most appropriate tooth size and shape and determine their relation.

Several methods have been used to measure the size of the maxillary anterior teeth.[13-18] Sterrett et al[6] studied the width/length ratio of the clinical crowns of the maxillary anterior teeth by using diagnostic casts of a sample of 71

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## Clinical Implications

This study documents tooth dimensions and proportions that may serve as useful guidelines in the diagnosis and treatment planning of esthetic restorations to achieve a natural-looking dental appearance that is also esthetically pleasing.

individuals and obtained a mean value for the 3 types of teeth of 81% and a mean value for maxillary central incisors of 85%. A similar study at the University of Geneva in 2003 made the measurements from photographs of extracted teeth and obtained an average value width/length ratio for the clinical crowns in the 3 types of teeth of approximately 75%.[7] In 2007, Chu and Hochman[10] introduced an innovative esthetic measurement gauge with the purpose of enabling the clinician to perform esthetic surgical and restorative dentistry with predictability. These authors set the width/length ratio at 78%.[8,10] Others have reported that the ideal width/length ratio for the central incisor should be between 75% and 80%.[11] Rosenstiel et al[12] evaluated dentists' preferred maxillary anterior tooth proportions and found that the majority chose smile proportions that resulted in central incisors that were closer to 75% and 78% width/length ratios.

Lombardi[19] was the first to suggest applying the golden proportion to dentistry; he also described the use of a "repeated ratio" in the maxillary anterior teeth. Levin[20] agreed that the golden proportion (62%) was the most harmonious recurrent tooth-to-tooth ratio from a frontal view. However, conflicting reports indicate that the proportion of the majority of beautiful smiles did not agree with the golden proportion formula.[12,21] Ward[21] recommended using other tooth-to-tooth ratios, such as 70% for normal length teeth, 62% for very long teeth, and 80% for very short teeth. He had asked several North American dentists about their esthetic preferences when looking at pictures of smiles with different proportions.

The definition of ideal tooth dimensions remains a difficult task because of individual variations. This study aimed to obtain dimensional data of the clinical crowns of the maxillary central incisors, lateral incisors, and canines of an adult population with respect to width, length, and width/length ratios and to determine whether a correlation exists between natural tooth dimensions and the guidelines of ideal tooth dimensions for treatment planning suggested for esthetic restorative dentistry.[10,12,21]

## MATERIAL AND METHODS

The sample used in this study consisted of 412 healthy participants, chosen from a population of European origin that met the following requirements: adults with all of the 6 maxillary anterior teeth present, anatomically whole, without restorations that altered their dimensions, from which good diagnostic casts could be obtained, and where the anatomic elements were well defined. Exclusion criteria were as follows: children (younger than 18 years); those with signs of gingival alteration, hyperplasia, inflammation, altered passive eruption, or gingival recession; history of periodontal surgery or clinical evidence or history of alteration of the incisal or proximal surfaces of the tooth; and those with restorations, traumatisms, attrition, occlusal adjustment, dental malformation, malposition or diastema, or previous orthodontic treatment.

Maxillary impressions were made with irreversible hydrocolloid material (VIVAL NF, Ivoclar Vivadent AG), and improved stone (Kromotypo Type 4, LASCOD Spa) was poured to obtain the diagnostic casts on which to make the measurements. An extra-fine end digital caliper (Tesa Digit-Cal SM) was used to obtain the measurements, with a precision of 0.01 mm. The measurements were all recorded in millimeters by a previously trained examiner (A.O.V.). The maximum mesiodistal width (perpendicular to the longitudinal axis of the tooth) and the maximum crown-root length, (parallel to the longitudinal axis of the tooth and between the most apical point of the gingival margin and the most incisal point of the anatomic crown) of the maxillary central incisors, lateral incisors, and canines was recorded for each tooth and the scores arranged in a table. The age and sex of each participant was also recorded.

The descriptive statistical analysis was carried out with software (SPSS Statistics v22.0; IBM Corp). In order to establish the diagnostic agreement of the measuring method, 40 casts were chosen from the 412 casts. In these 40 casts, 4 of the 12 measurements were carried out again (2 lengths and 2 widths), first by the same examiner (A.O.V.) and a week later by a second examiner (G.A.C.). The intraclass correlation coefficient (ICC) of both the intraexaminer and interexaminer was established.

A 1-way MANOVA test was carried out to identify differences due to sex. The result was positive, and the ANOVA test was then carried out to establish which of the dental measurements were affected. The ICC was also used to determine whether there was symmetry between right and left sides. The descriptive data obtained in this study were compared with data reported by other authors in similar studies.

## RESULTS

The sample was 60.7% female and 39.3% male, with a mean age of 33.94 years. Table 1 lists the results of the ICC used to assess the method's reliability. In all instances, the intraexaminer and interexaminer correlation was greater than 0.75, which, according to Fleiss,[22] is

**Table 1.** Interclass correlation coefficient (ICC) for intraexaminer and interexaminer values

| Tooth Dimension | Intraexaminer | Interexaminer |
|---|---|---|
| Right canine L | 0.85 | 0.94 |
| Left central W | 0.92 | 0.95 |
| Right central W | 0.98 | 0.93 |
| Left lateral L | 0.92 | 0.97 |

L, length; W, width.

considered excellent The mean error between the different measures/examiners was 0.16 (twice by the same examiner and once by a different one).

The mean, standard deviation (SD), and range of the width, length, and width/length ratio for each tooth individually and within its type of tooth are listed in Table 2. The mean width value was 8.71 mm for the central incisors, 6.75 mm for the lateral incisors, and 7.81 mm for the canines. The mean length was 10.23 mm for the central incisors, 8.59 mm for the lateral incisors, and 9.93 mm for the canines. The average width/length ratio was 85% for the central incisors and 79% for the laterals and canines.

Table 3 lists the mean, standard deviation (SD), and range of width, length, and width/length ratio for each tooth and sex. When the mean width and length values for the 3 tooth groups were compared between sexes, the mean coronal width and length measurements were found to be significantly greater in men than in women.

Table 4 lists the results of the 1-way MANOVA test with the different tooth groups noted as 3 dependent variables and the sex as the between subjects factor. A statistically significant difference was found between the sexes: F (12.390)=10.27, $P<.001$; Wilks' $\Lambda=0.760$, partial n2=.24. After applying the 1-way ANOVA test (Supplemental Table 1, available online), it was found that the sex differences affected all the dental dimensions of width and length ($P<.001$).

The mouth was considered to be more symmetrical when the values obtained for the same type of tooth in each half-arch were more similar. The ICC values were greater than 0.75 for all the tooth pairs and in both dimensions (Table 5), which is considered excellent.[22]

The dimensions of each tooth and for each participant were divided to compare tooth pairs from different types of teeth. This division led to the proportional values for each of the participants (Table 6). The ratio of the lateral width to the central width was 1.27:1. Table 7 compares the average values obtained in this study with those obtained by other authors in similar studies.

## DISCUSSION

The sample for this study included 412 participants, which is greater than the sample size of similar studies.[6-9,13-18]All of these articles refer to statistically significant results. The measurements were made on cast models following the method used by other authors.[6,9,14,17] The error linked to using the direct technique was similar or equal to other errors considered acceptable for dental measuring studies mentioned in other articles.[16]

The data obtained from other articles established the following ranking for maxillary crown width and length for the population studied: centrals > canines > laterals. The most noticeable differences in the mean values of length were found in studies that measured extracted teeth,[7,15] that is, from the incisal edge to the cementoenamel junction rather than the gingival margin, leading to greater length values and therefore smaller ratios (width/length ratio of 78% for central incisors). This is mentioned by Magne et al[7] and Marcushamer et al,[15] who noticed that their measurements were approximately 1 mm longer than those of other studies measuring clinical crowns and not anatomic crowns. This may account for why, when this ratio is applied clinically, the resulting teeth appear excessively long. However, these data may be useful in patients where crown lengthening techniques are applied and the cementoenamel junction is exposed.

The results of our study match those of other authors using the same measuring method.[6,17] Different data were recorded by Hasanreisoglu et al,[9] who found a width/length ratio of 89% for central incisors. The maxillary anterior teeth of the Turkish population sample studied displayed a more square-like shape because the teeth may be shorter in height and/or greater in width than those of other European populations.

The width/length ratio for each tooth has clinical relevance; knowing it allows a calculation of the lost length from the existing width, which usually remains stable. The results show an average ratio of 85% for maxillary central incisors and 79% for laterals and canines. These findings are in agreement with the results of other studies[6,14,17,18] but disagree with other reports that suggest ideal tooth dimension guidelines based on the preferences and esthetic perception of dentists; these seem to prefer central incisors that were closer to the 75% to 78% width/length ratios.[8,12,21]

The present results agree with the proportion thought of as ideal for maxillary laterals and canines. The obtained ratio width/length for the central incisors in our study (85%) is very similar to the one preferred by patients in the study of Cooper et al[5] in 2012, where smiles which had central incisors with a ratio width/length of 82% were considered the most attractive. However, it exceeds the ideal ratio for central incisors according to other authors who focus their studies on the harmonically esthetic perception of different examiners and not on actual tooth measurements. Rosenstiel et al[12] and Ward,[21] for example, evaluated the dentists' preferred maxillary anterior tooth proportions from a frontal view

**Table 2.** Mean (mm), range (min and max), and standard deviations (SD) of width, length, and width/length ratio for each tooth individually and within its type of tooth

| Dimension | Left Canine | Left Lateral | Left Central | Right Central | Right Lateral | Right Canine | Central Incisors | Lateral Incisors | Canines |
|---|---|---|---|---|---|---|---|---|---|
| Length | | | | | | | | | |
| Min | 7.92 | 6.27 | 8.00 | 8.00 | 6.00 | 7.77 | 8.00 | 6.14 | 7.94 |
| Mean | 9.90 | 8.54 | 10.22 | 10.23 | 8.64 | 9.97 | 10.23 | 8.59 | 9.93 |
| Max | 12.95 | 11.2 | 13.40 | 13.44 | 11.36 | 12.80 | 13.40 | 11.01 | 12.35 |
| SD | 0.8808 | 0.7678 | 0.7766 | 0.7858 | 0.8288 | 0.9589 | 0.7656 | 0.7584 | 0.8848 |
| Width | | | | | | | | | |
| Min | 6.51 | 5.06 | 7.26 | 7.17 | 5.10 | 6.63 | 7.30 | 5.33 | 6.71 |
| Mean | 7.83 | 6.74 | 8.71 | 8.71 | 6.77 | 7.78 | 8.71 | 6.75 | 7.81 |
| Max | 9.00 | 8.54 | 10.13 | 10.30 | 8.19 | 9.15 | 10.13 | 8.35 | 8.91 |
| SD | 0.4669 | 0.5640 | 0.5331 | 0.5269 | 0.5652 | 0.4530 | 0.5154 | 0.5380 | 0.4387 |
| Ratio | | | | | | | | | |
| Min | 0.60 | 0.49 | 0.67 | 0.68 | 0.57 | 0.60 | 0.68 | 0.55 | 0.63 |
| Mean | 0.79 | 0.79 | 0.85 | 0.85 | 0.78 | 0.78 | 0.85 | 0.79 | 0.79 |
| Max | 1.03 | 1.04 | 1.03 | 1.07 | 1.06 | 0.98 | 1.03 | 1.04 | 1.00 |
| SD | 0.0665 | 0.0766 | 0.0626 | 0.0650 | 0.8034 | 0.0693 | 0.0618 | 0.0746 | 0.0633 |

**Table 3.** Data distributed by sex: Mean (mm) and standard deviations (SD) of width, length, and width/length ratio for each tooth individually

| Dimension | Left Canine | Left Lateral | Left Central | Right Central | Right Lateral | Right Canine |
|---|---|---|---|---|---|---|
| Length | | | | | | |
| Mean, female | 9.63 | 8.43 | 10.06 | 10.08 | 8.55 | 9.67 |
| Mean, male | 10.31 | 8.70 | 10.47 | 10.47 | 8.78 | 10.43 |
| SD, female | 0.7637 | 0.7474 | 0.7101 | 0.7202 | 0.8096 | 0.8283 |
| SD, male | 0.8935 | 0.7719 | 0.8113 | 0.8271 | 0.8409 | 0.9665 |
| Width | | | | | | |
| Mean, female | 7.71 | 6.65 | 8.60 | 8.61 | 6.69 | 7.66 |
| Mean, male | 8.02 | 6.87 | 8.87 | 8.87 | 6.90 | 7.96 |
| SD, female | 0.4494 | 0.5573 | 0.5200 | 0.5212 | 0.5668 | 0.4141 |
| SD, male | 0.4317 | 0.5509 | 0.5114 | 0.4972 | 0.5404 | 0.4511 |
| Ratio | | | | | | |
| Mean, female | 0.80 | 0.79 | 0.85 | 0.85 | 0.78 | 0.79 |
| Mean, male | 0.78 | 0.79 | 0.85 | 0.85 | 0.79 | 0.76 |
| SD, female | 0.0619 | 0.0753 | 0.0602 | 0.0609 | 0.0856 | 0.0623 |
| SD, male | 0.0711 | 0.0789 | 0.0663 | 0.0708 | 0.0802 | 0.0761 |

**Table 4.** One-way MANOVA to determine sex differences

| Effect | Value | F | Partial $\eta^2$ | Noncent Parameter | Observed Power* |
|---|---|---|---|---|---|
| Intercept | | | | | |
| Pillai's trace | .998 | 15268.047 | .998 | 183216.565 | 1.000 |
| Wilks' Lambda | .002 | 15268.047 | .998 | 183216.565 | 1.000 |
| Hotelling's trace | 469.786 | 15268.047 | .998 | 183216.565 | 1.000 |
| Roy's largest root | 469.786 | 15268.047 | .998 | 183216.565 | 1.000 |
| Sex | | | | | |
| Pillai's trace | .240 | 10.267 | .240 | 123.205 | 1.000 |
| Wilks' Lambda | .760 | 10.267 | .240 | 123.205 | 1.000 |
| Hotelling's trace | .316 | 10.267 | .240 | 123.205 | 1.000 |
| Roy's largest root | .316 | 10.267 | .240 | 123.205 | 1.000 |

*df*, degree of freedom.
Design: intercept + sex. Confidence level used was <.001.
*Computed using $\alpha$ = .05; error *df*: 390.00; hypothesis *df*: 12.00.

**Table 5.** Interclass correlation coefficient for same tooth left and right sides

| Variable | Length | Width |
|---|---|---|
| Right/left central | 0.93 | 0.90 |
| Right/left canine | 0.90 | 0.80 |
| Right/left lateral | 0.79 | 0.81 |

and found that the majority chose smile proportions that resulted in central incisors with closer to 75% to 78% width/length ratios. Disagreement seems to exist between the values more frequently found when observing nature and what is thought of as the ideal.

Significant differences exist between the esthetic perceptions of dentists, technicians, and patients and there is lack of agreement within each group, in particular within the patient group. All of the aforementioned studies obtain width/length ratios for each individual tooth that differ from the Golden proportion of 62% supported by Levin.[20]

The results indicate that men have greater width and length measurements than women ($P$<.001), agreeing with most of the existing literature, which considers that maxillary anterior teeth in men are between approximately 0.5 mm and 1 mm longer.[6,8,9] However, the sex differences disappear with regard to the width/length ratio. These findings are supported by other studies[6,9,18] wherein the maxillary canines tend to exhibit the greatest sex-based morphologic difference compared with other teeth.

A strong positive correlation was found between the left and right maxillary central incisors. The lowest correlation was found in the length of the maxillary lateral incisors. Chu[8] also noticed an asymmetry of approximately 0.5 mm difference between the measurements of the right and left side and considered it to

**Table 6.** Combined ratios of right and left sides for entire sample

| Variable* | Mean | Range |
|---|---|---|
| L lateral/ L central | 0.84 | 0.68-1.01 |
| L canine/ L central | 0.97 | 0.78-1.27 |
| L lateral/ L canine | 0.86 | 0.68-1.06 |
| W lateral/ W central | 0.77 | 0.59-0.95 |
| W canine/ W central | 0.94 | 0.74-1.06 |
| W lateral/ W canine | 0.87 | 0.68-1.06 |

W/W= ratios of maximum widths.
*L/L = length ratios of lateral incisor to central incisor, canine to central incisor, and lateral incisor to canine.

**Table 7.** Results comparison with previous studies

| Study | N | CIL | LIL | CL | CIW | LIW | CW | CIR | LIR | CR |
|---|---|---|---|---|---|---|---|---|---|---|
| Orozco 2013 | 412 | 10.23 | 8.59 | 9.93 | 8.71 | 6.75 | 7.81 | 0.85 | 0.79 | 0.79 |
| Sterrett[6] 1999 | 71 | 9.79 | 8.24 | 9.5 | 8.32 | 6.36 | 7.4 | 0.85 | 0.78 | 0.79 |
| Magne[7] 2003 | 146 | 11.69 | 9.75 | 10.83 | 9.10 | 7.07 | 7.90 | 0.78 | 0.73 | 0.73 |
| Hasanreisoglu[9] 2005 | 100 | 9.6 | 8.17 | 9.05 | 8.6 | 6.7 | 7.7 | 0.89 | 0.82 | 0.85 |
| Zlataric[14] 2007 | 90 | - | - | - | - | - | - | 0.83 | 0.78 | 0.81 |
| Marcushamer[15] 2011 | 264 | 11.93 | 10.52 | 11.83 | 8.63 | 6.99 | 7.91 | 0.72 | 0.67 | 0.67 |
| Guillen[16] 1994 | 54 | 10.27 | 8.72 | 10.15 | 9.28 | 7.35 | 8.36 | 0.90 | 0.84 | 0.82 |
| Mavroskoufis[17] 1980 | 70 | 10.42 | - | - | 8.88 | - | - | 0.85 | - | - |
| Zagar[18] 2001 | 78 | - | - | - | - | - | - | 0.86 | 0.82 | 0.81 |

CIL: central incisor length, LIL: lateral incisor length, CL: canine length, LIW: central incisor width, LIW: lateral incisor width, CW: canine width, CIR: central incisor ratio, LIR: lateral incisor ratio, CR: canine ratio. -: unregistered. Measures in millimeters.

be within the normal range of asymmetry for the human body.

The width lateral incisor/width central incisor ratio was also obtained in this study by measuring directly on the casts, thus incorporating the real tooth width. The results match those of other authors who carried out similar studies,[6-8,16] with the width of the lateral incisor being 77% of the width of the central incisor, a ratio of 1.27:1. However, the studies that calculate ratios from a photograph use only the portion of the tooth that is visible from the frontal aspect, obtaining width lateral incisor/width central incisor values of 67%.[13] Once again, there is no correlation between these proportions and the golden proportion, which describes the ratio between centrals and laterals as 62%, a ratio of 1.62:1. When the golden proportion is used, the lateral incisors and canines appear narrow.

## CONCLUSIONS

This work investigated the clinical crown of the 3 anterior maxillary tooth groups from a white European population sample (maxillary central incisors, lateral incisors, and canines) with respect to width, length, and width/length ratios. Within the limitations of the present study, the following conclusions were drawn:

1. Central incisors had the widest crowns (8.71 mm), followed by canines (7.81 mm) and lateral incisors (6.75 mm). Central incisors also had the longest crowns (10.23 mm), followed by canines (9.93 mm) and lateral incisors (8.59 mm). The average width/length ratio was 85% for central incisors and 79% for laterals and canines. Therefore, the average width/length ratio in the maxillary anterior region of the mouth is 81%.
2. The average ratio between the width of the maxillary central incisors and the laterals was 1.27:1. The golden proportion was not found in this study sample.
3. Sex should be taken into account when estimating tooth size. Significant differences were found, with men having greater values for both length and width than women. The canine was the tooth affected most by sex difference.
4. When left and right sides were analyzed, central incisors were found to be more symmetrical than canines, and these more than lateral incisors.
5. The information obtained from this population sample is similar to that of other studies applying the same methodology in populations of European origin. Greater discrepancies were found when compared with other studies that suggest guidelines of ideal tooth dimensions based on the preferences and esthetic perception of dentists. This information may be useful in conjunction with other clinical parameters for diagnosis and treatment planning to achieve natural looking and esthetically pleasing restorations.
6. More studies are needed that record the patients' perception of different dental proportions.

## REFERENCES


1. Carlsson GE, Johansson A, Johansson AK, Ordell S, Ekbäck G, Unell L. Attitudes toward dental appearance in 50- and 60-year-old subjects living in Sweden. J Esthet Restor Dent 2008;20:46-56.
2. Scoble HO, White SN. Compound complex curves: the authentic geometry of aesthetic dentistry. J Prosthet Dent 2014;111:448-54.
3. Noureddine A, Fron Chabouis H, Parenton S, Lasserre JF. Laypersons' esthetic perception of various computer-generated diastemas: a pilot study. J Prosthet Dent 2014;112:914-20.
4. De-Marchi LM, Pini NI, Ramos AL, Pascotto RC. Smile attractiveness of patients treated for congenitally missing maxillary lateral incisors as rated by dentists, laypersons, and the patients themselves. J Prosthet Dent 2014;112:540-6.
5. Cooper GE, Tredwin CJ, Cooper NT, Petrie A, Gill DS. The influence of maxillary central incisor height-to-width ratio on perceived smile aesthetics. Br Dent J 2012;212:589-99.
6. Sterrett JD, Oliver T, Robinson F, Fortson W, Knaak B, Russell CM. Width/length ratios of normal clinical crowns of the maxillary anterior dentition in man. J Clin Periodontol 1999;26:153-7.
7. Magne P, Gallucci GO, Belser UC. Anatomic crown width/length ratios of unworn and worn maxillary teeth in white subjects. J Prosthet Dent 2003;89:453-61.
8. Chu SJ. Range and mean distribution frequency of individual tooth width of the maxillary anterior dentition. Pract Proced Aesthet Dent 2007;19:209-15.
9. 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.
10. Chu SJ, Hochman MN. A biometric approach to aesthetic crown lengthening: part I-midfacial considerations. Pract Proced Aesthet Dent 2008;20:17-24.

11. Gl Chiche, Pinault A. Aesthetic of anterior fixed prosthodontics. Chicago: Quintessence; 1994. p. 61-5.
12. Rosenstiel SF, Ward DH, Rashid RG. Dentist's preferences of anterior tooth proportion—a web-based study. J Prosthodont 2000;9:123-36.
13. Mahshid M, Khoshvaghti A, Varshosaz M, Vallaei N. Evaluation of "golden proportion" in individuals with an aesthetic smile. J Esthet Restor Dent 2004;16:185-92.
14. Zlataric DK, Kristek E, Celebic A. Analysis of width/length ratios of normal clinical crowns of the maxillary anterior dentition: correlation between dental proportion and facial measurements. Int J Prosthodont 2007;20:313-5.
15. Marcushamer E, Tsukiyama T, Griffin TJ, Gallucci GO, Magne P. Anatomical crown width/length ratios of worn and unworn maxillary teeth in Asian subjects. Int J Periodontics Restorative Dent 2011;31:495-503.
16. Gillen RJ1, Schwartz RS, Hilton TJ, Evans DB. An analysis of selected normative tooth proportions. Int J Prosthodont 1994;7:410-7.
17. Mavroskoufis F, Ritchie GM. Variation in size and form between left and right maxillary central incisor teeth. J Prosthet Dent 1980;43:254-7.
18. Zagar M. Influence of aesthetic dental and facial measurements on the Caucasian patients' satisfaction. J Esthet Restor Dent 2011;23:12-21.
19. Lombardi RE. The principles of visual perception and their application to denture aesthetics. J Prosthet Dent 1973;29:358-63.
20. Levin EI. Dental esthetics and the golden proportion. J Prosthet Dent 1978;40:244-52.
21. Ward DH. A study of dentists' preferred maxillary anterior tooth width proportions: comparing the recurring aesthetic dental proportion to other mathematical and naturally occurring proportions. J Esthet Restor Dent 2007;19:324-39.
22. Fleiss JL. The design and analysis of clinical experiments. New York: John Wiley & Sons; 1986. p. 17-28.

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## Noteworthy Abstracts of the Current Literature

### Microtensile bond strength of different acrylic to high-impact denture base resin

Colebeck AC, Monaco EA, Rusateri CR, Davis EL
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**Purpose.** This study evaluated the effect of denture base acrylic, denture tooth composition, and ridge-lap surface treatment on the microtensile bond strength (μTBS) of three commercially available denture teeth and two injection denture processing systems.

**Materials and Methods.** Sixteen experimental groups were formed (n = 3), according to denture tooth surface treatment (no treatment or surface treatment recommended by the manufacturer), denture base processing technique and acrylic (SR-Ivocap-Ivocap Plus or Success-Lucitone 199), and tooth type-composition at bonding interface (BlueLine DCL-PMMA, Portrait IPN-PMMA, Phonares II-PMMA, Phonares II-NHC). Rectangular bar specimens with a 1 mm(2) cross sectional area were fabricated and subsequently thermocycled at 10,000 cycles between 5°C and 55°C with a 15-second dwell time. Select specimens underwent μTBS testing in a universal testing machine with a 1 kN load cell at 0.5 mm/min crosshead speed. Data were analyzed statistically by two and three-way ANOVA and Tukey post hoc test ($\alpha = 0.05$).

**Results.** Mean μTBS ranged between 56.2 ± 5.6 and 60.8 ± 5.0 N/mm(2) for the Ivocap Plus specimens and 13.3 ± 5.12 to 60.1 ± 6.0 N/mm(2) for the Lucitone 199 specimens. Among the Ivocap specimens, BlueLine DCL and Phonares II NHC had significantly higher μTBS than Portrait IPN to Ivocap Plus acrylic. There were no statistically significant differences among Blueline, Phonares II PMMA, and Phonares II NHC, or between Phonares II PMMA and Portrait IPN. Within the Luctione 199 specimens, there was a significantly higher μTBS for BlueLine DCL and Phonares II NHC denture teeth with the manufacturer-recommended surface treatment when compared to control surface. BlueLine, Portrait, and Phonares II PMMA groups achieved significantly higher mean μTBS than the Phonares II NHC group. There were no statistically significant differences among BlueLine, Portrait, and Phonares II PMMA groups.

**Conclusions.** When evaluating the μTBS of PMMA and NHC denture teeth to base resins, a stronger bond was achieved using materials produced by the same manufacturer. Within the Luctione 199 specimens, the Phonares II NHC group demonstrated significantly lower bond strength than other specimens, suggesting that gross ridge-lap reduction of NHC denture teeth is not recommended if a base acrylic by a different manufacturer from the tooth is going to be used.

**Supplemental Table 1.** 1-way ANOVA comparing sex with each of mean values

**Tests of Between Subjects Effects**

| Source | Dependent Variable | Type III Sum of Squares | *df* | Mean Square | F | Sig. | Partial $\eta^2$ | Noncent Parameter | Observed Power* |
|---|---|---|---|---|---|---|---|---|---|
| Corrected model | Right canine L | 46.074[a] | 1 | 46.074 | 69.329 | .001 | .147 | 69.329 | 1.000 |
| | Right lateral L | 7.235[b] | 1 | 7.235 | 12.552 | .001 | .030 | 12.552 | .942 |
| | Right central L | 16.507[c] | 1 | 16.507 | 29.460 | .001 | .068 | 29.460 | 1.000 |
| | Left central L | 14.774[d] | 1 | 14.774 | 25.261 | .001 | .059 | 25.261 | .999 |
| | Left lateral L | 5.404[e] | 1 | 5.404 | 7.891 | .005 | .019 | 7.891 | .800 |
| | Left canine L | 57.398[f] | 1 | 57.398 | 73.098 | .001 | .154 | 73.098 | 1.000 |
| | Right canine W | 9.415[g] | 1 | 9.415 | 48.402 | .001 | .108 | 48.402 | 1.000 |
| | Right lateral W | 4.717[h] | 1 | 4.717 | 15.550 | .001 | .037 | 15.550 | .976 |
| | Right central W | 7.241[i] | 1 | 7.241 | 27.200 | .001 | .064 | 27.200 | .999 |
| | Left central W | 6.903[j] | 1 | 6.903 | 26.734 | .001 | .063 | 26.734 | .999 |
| | Left lateral W | 4.207[k] | 1 | 4.207 | 14.017 | .001 | .034 | 14.017 | .962 |
| | Left canine W | 8.939[l] | 1 | 8.939 | 48.969 | .001 | .109 | 48.969 | 1.000 |
| Intercept | Right canine L | 38430.111 | 1 | 38430.111 | 57826.391 | .001 | .993 | 57826.391 | 1.000 |
| | Right lateral L | 28383.988 | 1 | 28383.988 | 49241.000 | .001 | .992 | 49241.000 | 1.000 |
| | Right central L | 40765.085 | 1 | 40765.085 | 72752.098 | .001 | .995 | 72752.098 | 1.000 |
| | Left central L | 40823.565 | 1 | 40823.565 | 69803.083 | .001 | .994 | 69803.083 | 1000 |
| | Left lateral L | 29059.221 | 1 | 29059.221 | 42433.244 | .001 | .991 | 42433.244 | 1.000 |
| | Left canine L | 39094.101 | 1 | 39094.101 | 49787.022 | .001 | .992 | 49787.022 | 1.000 |
| | Right canine W | 23922.298 | 1 | 23922.298 | 122978.399 | .001 | .997 | 122978.399 | 1.000 |
| | Right lateral W | 17645.514 | 1 | 17645.514 | 58172.733 | .001 | .993 | 58172.733 | 1.000 |
| | Right central W | 29514.980 | 1 | 29514.980 | 110877.061 | .001 | .996 | 110877.061 | 1.000 |
| | Left central W | 29527.537 | 1 | 29527.537 | 114349.859 | .001 | .997 | 114349.859 | 1.000 |
| | Left lateral W | 17821.780 | 1 | 17821.780 | 59380.562 | .001 | .993 | 59380.562 | 1.000 |
| | Left canine W | 23598.209 | 1 | 23598.209 | 129269.225 | .001 | .997 | 129269.225 | 1.000 |
| Sex | Right canine L | 46.074 | 1 | 46.074 | 69.329 | .001 | .147 | 69.329 | 1.000 |
| | Right lateral L | 7.235 | 1 | 7.235 | 12.552 | .001 | .030 | 12.552 | .942 |
| | Right central L | 16.507 | 1 | 16.507 | 29.460 | .001 | .068 | 29.460 | 1.000 |
| | Left central L | 14.774 | 1 | 14.774 | 25.261 | .001 | .059 | 25.261 | .999 |
| | Left lateral L | 5.404 | 1 | 5.404 | 7.891 | .005 | .019 | 7.891 | .800 |
| | Left canine L | 57.398 | 1 | 57.398 | 73.098 | .001 | .154 | 73.098 | 1.000 |
| | Right canine W | 9.415 | 1 | 9.415 | 48.402 | .001 | .108 | 48.402 | 1.000 |
| | Right lateral W | 4.717 | 1 | 4.717 | 15.550 | .001 | .037 | 15.550 | .976 |
| | Right central W | 7.241 | 1 | 7.241 | 27.200 | .001 | .064 | 27.200 | .999 |
| | Left central W | 6.903 | 1 | 6.903 | 26.734 | .001 | .063 | 26.734 | .999 |
| | Left lateral W | 4.207 | 1 | 4.207 | 14.017 | .001 | .034 | 14.017 | .962 |
| | Left canine W | 8.939 | 1 | 8.939 | 48.969 | .001 | .109 | 48.969 | 1.000 |
| Error | Right canine L | 266.496 | 401 | .665 | | | | | |
| | Right lateral L | 231.148 | 401 | .576 | | | | | |
| | Right central L | 224.692 | 401 | .560 | | | | | |
| | Left central L | 234.520 | 401 | .585 | | | | | |
| | Left lateral L | 274.614 | 401 | .685 | | | | | |
| | Left canine L | 314.876 | 401 | .785 | | | | | |
| | Right canine W | 78.004 | 401 | .195 | | | | | |
| | Right lateral W | 121.635 | 401 | .303 | | | | | |
| | Right central W | 106.744 | 401 | .266 | | | | | |
| | Left central W | 103.547 | 401 | .258 | | | | | |
| | Left lateral W | 120.351 | 401 | .300 | | | | | |
| | Left canine w | 73.203 | 401 | .183 | | | | | |
| Total | Right canine L | 39805.056 | 403 | | | | | | |
| | Right lateral L | 29627.769 | 403 | | | | | | |
| | Right central L | 42379.498 | 403 | | | | | | |
| | Left central L | 42466.776 | 403 | | | | | | |
| | Left lateral L | 30396.820 | 403 | | | | | | |

(*continued on next page*)

**Supplemental Table 1.** 1-way ANOVA comparing sex with each of mean values (*continued*)

| Tests of Between Subjects Effects | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **Source** | **Dependent Variable** | **Type III Sum of Squares** | ***df*** | **Mean Square** | **F** | **Sig.** | **Partial $\eta^2$** | **Noncent Parameter** | **Observed Power*** |
| | Left canine L | 40487.088 | 403 | | | | | | |
| | Right canine W | 24818.402 | 403 | | | | | | |
| | Right lateral W | 18394.065 | 403 | | | | | | |
| | Right central W | 30678.160 | 403 | | | | | | |
| | Left central W | 30692.219 | 403 | | | | | | |
| | Left lateral W | 18582.086 | 403 | | | | | | |
| | Left canine W | 24481.779 | 403 | | | | | | |
| Corrected total | Right canine L | 312.570 | 402 | | | | | | |
| | Right lateral L | 238.384 | 402 | | | | | | |
| | Right central L | 241.199 | 402 | | | | | | |
| | Left central L | 249.294 | 402 | | | | | | |
| | Left lateral L | 280.017 | 402 | | | | | | |
| | Left canine L | 372.274 | 402 | | | | | | |
| | Right canine W | 87.420 | 402 | | | | | | |
| | Right lateral W | 126.352 | 402 | | | | | | |
| | Right central W | 113.985 | 402 | | | | | | |
| | Left central W | 110.450 | 402 | | | | | | |
| | Left lateral W | 124.558 | 402 | | | | | | |
| | Left canine W | 82.142 | 402 | | | | | | |

L, length; W, width; *df*, degree of freedom.
*Computed using $\alpha = .01$.
[a]$R^2$=.147; [b]$R^2$=.030; [c]$R^2$=.068; [d]$R^2$=.059; [e]$R^2$=.019; [f]$R^2$=.154; [g]$R^2$=.108; [h]$R^2$=037; [i]$R^2$=.064; [j]$R^2$=.063; [k]$R^2$=.034; [l]$R^2$=.109.