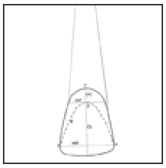
Assessment of Maxillary Central Incisor Crown Form



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Incisor crown form is thought to be associated with different periodontal features and it is hypothesized that there are measures in the maxillary central incisor that can be used to characterize its form. The aim of this study was to assess maxillary central incisor crown dimensions to determine morphologic groups. One-hundred fifty sound maxillary central incisors without excessive evidence of incisal wear were utilized. On each crown, several reference points were marked and mesiodistal and axial diameters were measured using a digital caliper. A ratio between the minor and major mesiodistal diameters was made to assess dental forms. Maxillary central incisor form was categorized into three groups based on the upper limits of three intervals as cutoff points. The measurements were performed in a double blind fashion. The reliability of measurements was estimated by the Pearson correlation coefficient for each tooth, setting a value > 0.8. The percentage of maxillary central incisors in each group was: 20.67% for group 1, 22.67% for group 2, and 56.67% for group 3. The results suggest that maxillary central incisor morphology can be properly assessed through quantifiable methods. The minor/major mesiodistal ratio is simple, quantitative, and easily reproduced. It is a quantifiable definition of dental forms based on characters that are not modified because of the position of the gingival margin or incisal wear. Hence, the grade of cervical convergence could help clinicians assess tooth shape before performing restorative, orthodontic, or surgical treatments. (Int J Periodontics Restorative Dent 2013;33:XXX–XXX)

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In dentistry, biotype is used to group individuals that share a series of dental and periodontal aspects.[1] Periodontal biotypes have been linked to the outcomes of periodontal and implant therapy.[2] Thus, treatment planning should take into account the periodontal biotype because thin biotypes demonstrate healing that often leads to recession.[3] The morphologic characteristics of the periodontium in general are related to the shape and size of the teeth, which are an expression of the biotype.[4] To define dental forms, the maxillary central incisor is used as reference. The differences between biotypes are more explicit in this tooth, and their specific features are easily found in other parts of the dentition.[4,5]

When referring to the maxillary central incisor (MCI) form, the crown width/crown length ratio (CW/CL ratio) is used to differentiate two basic forms of clinical crowns: the long narrow and the short wide.[6] Although a significant difference between these dental forms and gingival thicknesses was not found,[4] many studies apply the CW/CL ratio in relation to

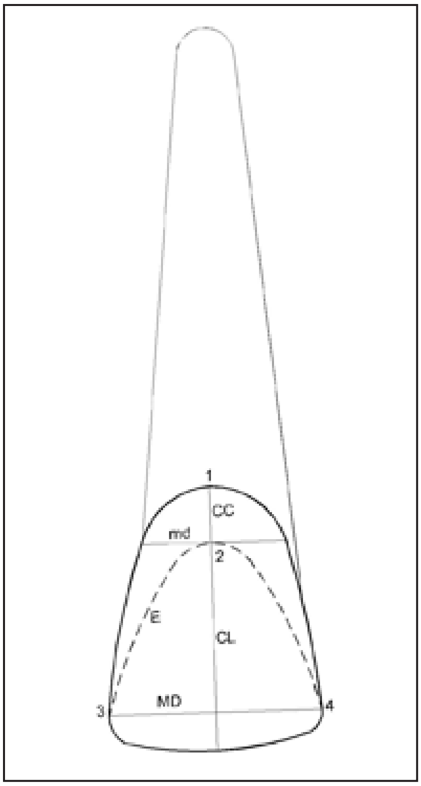

Fig 1 *Schematic representation of maxillary central incisor crown's labial aspect showing the references points and diameters measured. CC = cervical convexity; CL = crown length; md = mesiodistal minor diameter; MD = mesiodistal major diameter; E = anatomical equator; 1, 2 = facial reference points; 3, 4 = mesial and distal reference points.*

periodontal biotypes.[7] However, it was suggested that the problem of using the CW/CL ratio to identify the tooth form is mainly associated with difficulties in determining proper reference points because of incisal wear and/or the variable position of the gingival margin.[4]

Classic anatomical textbooks refer to three basic forms of the MCI, ie, rectangular, ovoidal, and triangular with a large range of intermediate forms. This classification is often used in restorative dentistry with intermediate forms being the most frequently observed; furthermore, this assessment is highly dependent on the clinician's perception.[8,9]

Some authors suggest that the grade of cervical convergence (GCC) of the proximal surfaces and the position of the contact areas modifies the facial aspect of the MCI.[10] Given the limitations found in relation to dental form classification criteria, the objective of this study was to asses MCI crown dimensions, based on the application of GCC, in order to determine morphologic groups.

Method and materials

One-hundred fifty randomized extracted maxillary central incisors from adults over 18 years of age were used in this study. All teeth were clean, free of restorations and decay, and without excessive evidence of incisal wear. A tooth was excluded in cases of exposed dentin.[6]

A Ney-type dental surveyor[11] was used to standardize the positions of the reference points. Each tooth was positioned on the cast holder of the surveyor, making its longitudinal axis parallel to the surveying arm, while the following reference points were marked. The maximum crown contour, also known as height of contour or anatomical equator (E) was drawn, considering E the resulting line produced by the union of the most prominent points of crown faces in relation to the longitudinal axis (Fig 1).[12]

Next, in the crown's labial aspect, the most apical point of the cementoenamel junction (CEJ) and E were highlighted, referred to as points 1 and 2, respectively. In the same manner, the most inci-

Table 1 **Axial and mesiodistal diameters of the sample (n = 150)**

Measurement	Mean ± SD (mm)	95% CI	Minimum–maximum
CL	10.88 ± 1.07	10.71; 11.06	7.8–13.2
CC	2.74 ± 0.66	2.63; 2.85	1.0–5.0
Major mesiodistal	8.58 ± 0.52	8.49; 8.66	7.45–10.06
Minor mesiodistal	6.67 ± 0.59	6.58; 6.77	5.2–8.0

SD = standard deviation, CI = confidence interval, CL = crown length, CC = cervical convexity.

sal point of E was marked over the mesial and distal surfaces, referred to as points 3 and 4 (Fig 1). After the before-mentioned reference points were properly marked, axial and mesiodistal measurements were done using a digital caliper (Mitutoyo).

The axial diameters (parallel to the longitudinal axis of the tooth) included *(1)* the inciso-cervical crown length (CL): distance between the CEJ (point 1) to the incisal edge of the crown and *(2)* the cervical axial diameter or cervical convexity (CC) measured from point 1 to labial point 2.

The mesiodistal diameters (perpendicular to the longitudinal axis of the tooth) included *(1)* the major mesiodistal from mesial point 3 to distal point 4 and *(2)* the minor mesiodistal: parallel to the major mesiodistal at labial point 2.

The measurements were performed in a double blind fashion, and the reliability of measurements was estimated with the Pearson correlation coefficient for each tooth, setting a value > 0.8. The teeth were encoded and delivered independently to each researcher. Following standardization and calibration exercises, the interexaminer and intraexaminer agreement was determined. Intraexaminer agreement procedures were performed with diameter-based scores. Each examiner (LS and JL) perfomed the whole process for each tooth tested (eg, dental survey mounting, drawing references points, measuring diameters). Since the final outcome of the procedure included the diameters for each tooth (CL, CC, and major and minor mesiodistal), these values were used as data-points.

Statistical model

To asses dental forms using the GCC, a variable called MCI form was built, calculated as a ratio between minor and major mesiodistal (MCI form = minor/major). The MCI form was categorized into three groups based on the upper limits of three intervals as cutoff points (group 1: 0.72, group 2: 0.83, group 3: 0.94). Cutoff points were obtained by dividing data rank in three. Given that the minor/major mesiodistal ratio shows a normal distribution, the upper limits of each interval represent one standard deviation ± the mean. Cluster validation of MCI forms was completed with two methods. A multinomial regression model was performed, with probability values calculated, estimating the misclassification error rate using leave-one-out cross-validation a posteriori. Linear discriminant method was also done, calculating the analysis of variance (ANOVA) univariate for the variables used for group characterization (CL, CC, minor and major mesiodistal).

Results

The descriptive measures of each variable studied are shown in Table 1. Cluster validation showed an accuracy of 89% (Table 2). MCI form was considered the outcome vari-

Table 2a Leave-one-out cross-validation classification with prognostic values estimated by multinomial model a posteriori

	Prognostic group (%)		
Observed md/MD	**Group 1**	**Group 2**	**Group 3**
Group 1	71.0	29.0	0.0
Group 2	2.9	91.2	5.9
Group 3	0.0	4.7	95.3

Correct classification of cases/prognostic group: 89.3%.

Table 2b Statistical significance of each variable included in order to determine MCI groups

Variable	ANOVA univariate *P*
CL	.3266
CC	.0003*
Major mesiodistal	.9637
Minor mesiodistal	< .0001*

ANOVA = analysis of variance, CL = crown length, CC = cervical convexity.
*indicates statistical significance; *P* value was fixed at < .05.

able, and the predictors were the axial and mesiodistal diameters. Figure 2 shows a linear discriminant graph where the morphologic group classification can be seen according to the above-mentioned variables (CL, CC, minor and major mesiodistal). The percent of MCI in each group was: group 1, 20.67%; group 2, 22.67%; and group 3, 56.67%.

Discussion

The results on anatomical crowns are similar to those in previous publications[9,13,14]; the values that could be compared were CL (10.88 mm, standard deviation [SD]: 1.07) and major mesiodistal (8.58 mm, SD: 0.52). Since it has been reported that there is no significant correlation between tooth shape and gender,[15,16] this variable was not employed in the study.

On the other hand, when referring to CL, the anatomical crown measurements (10.88 mm, SD: 1.07) were largerer than those for clinical crowns, as could be expected. For the latter, values from 9.8 mm, SD: 0.9[17] to 10.0 mm, SD: 1.00 [18] were found. This clearly shows the difference for this parameter when it is measured in real crown length (the so-called anatomical crown) versus its clinical appearance.

Measures of crown length are limited apically by the CEJ, which usually determines the structure and position of soft tissues.[19] Nonetheless, the relationship between CEJ and gingival level could show variations within and beyond normal range, sometimes exposing part of the root or covering enamel, eg, altered passive eruption (ALPE). This is a clinical condition that occurs after tooth eruption when the free gingival margin comes to rest at or coronal to the cervical bulge of the tooth.[20] It was stated that ALPE could be found in both thin and thick periodontal biotypes,[21] and this could induce diagnostic mistakes when the general practitioner tries to characterize dental forms. In this context, it seems more suitable to use the CEJ instead of the gingival margin as a reference to assess crown length. [22] Higher interdental bone height with overlying gingival papillae together with thin buccal gingiva may give the illusion of a long tooth, when it is actually of "average size."[23] Hence, crown height should not be used to define dental form, as its values are subject to great variations with time (eg, incisal wear and variable position of the gingival margin). For this reason, the GCC assessment was not integrated with crown height for this study. Moreover, the CL results did not show statistically significant differences between groups (Table 2).

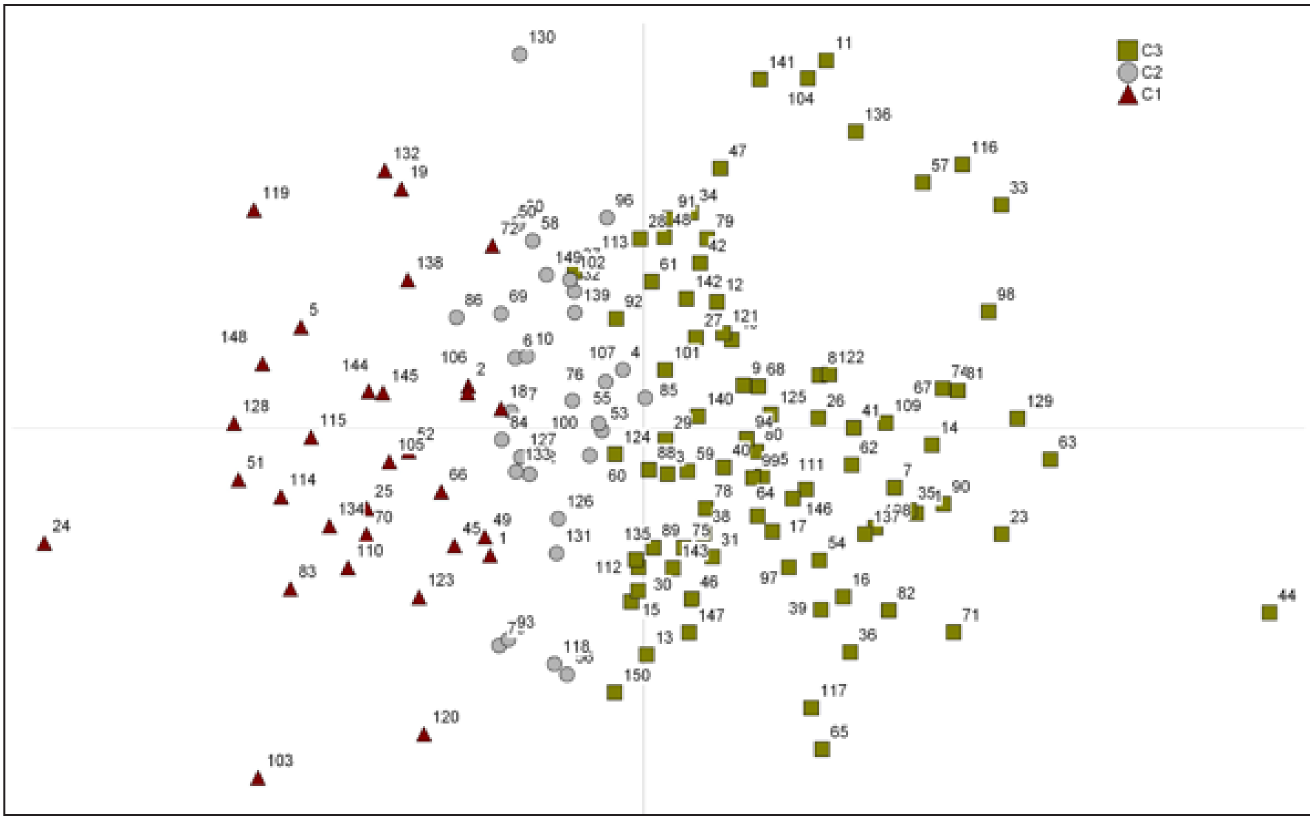

Fig 2 *Lineal discriminate graph. Red triangle = group 1 (narrow/strangled/very convergent), gray circle = group 2 (intermediate/moderate convergence), green square = group 3 (wide/stout/little convergence).*

In general, certain periodontal features, such as gingival thickness, are largely genetically determined, and appear to be strongly associated with tooth form.[1] The analysis of dental forms and their relationship with different periodontal features led to a trend of studies based on the CW/CL ratio.[23–25] However, a clinical report that applied this criterion did not find a statistically significant difference between dental forms and gingival thickness.[4] Moreover, this study describes only the extreme forms of the sample (short wide and long narrow), excluding the intermediates ones, which are the largest group. In the present study using the GCC, the largest group (group 3) comprised the stereotype of MCI as described by the literature.[9,10] However, the relationship between dental forms and periodontal biotype is far from being proven, and the GCC classification needs to be assessed in a clinical study.

When the CW/CL ratio is used in relation to the periodontal biotype, the results are inconsistent. Chow et al could associate competent papillae (complete fill of interdental space) with a CW/CL ratio of ≥ 0.87[26]; however, Chen et al could not use long narrow and short wide forms to explain gingival margin changes of immediate implant placements.[27] Kapferer et al was unable to relate labial piercing and gingival recessions using the CW/CL ratio.[28] The biotype concept covers dental shapes and other periodontal characteristics (eg, gingival thickness and width) working together. For this reason, the use dental forms only to ascertain biotype is a simplification and could induce errors.

It has been suggested that the gingival profile is related to the contour of the osseous crest, thus classifying the alveolar bone morphology into three basic types: flat, scalloped, or pronounced scalloped. Nevertheless, a definitive relationship between bone anatomy and tooth form assessed

Fig 3 *Clinical example of group 1 (narrow/strangled/very convergent).*

through the CW/CL ratio could not be found.[23] As suggested by the authors, this is probably because incisal wear was not estimated, and this may have affected the CW/CL ratio values. To sum up, several studies failed to find an association between CW/CL ratio and different periodontal aspects, and this can be ascribed to misclassification of forms using this this formula. The CW/CL ratio has wide limits to distinguish between only two extreme forms; besides, further clinical reports divided their samples into three groups. [24,25]

The three basic subjective MCI forms described (oval, rectangular, and triangular)[12] often cause problems at clinical assessment, because any of them could be found in short, medium, and long teeth, as well as in wide and narrow ones. [13] A study using the CW/CL ratio was conducted to evaluate visual inspection as a method to identify the gingival biotype, and it was found that nearly half of the cases were misclassified irrespective of the clinician's experience.[29] The authors suggest that direct inspection may not be considered a reliable approach to identify biotypes. Due to this, it appears that the GCC criterion provides a classification of dental forms based on objective parameters. This could improve the clinical approach to the anterior dentition of various dental disciplines.

To the best of the authors' knowledge, there are no studies to asses CW/CL ratio to recognize MCI forms, so a traditional criterion, such us grade of cervical convergence of the proximal surfaces, was chosen.[10] In this study, parameters not affected by either gingival position or incisal wear were used. To morphologically characterize a tooth, it seems logical to use the dental equator because it is a stable area in sound teeth, and its position changes with different forms of tooth. Moreover, the results display a sample distribution in agreement with classic textbooks of dental anatomy.[13,14] In this sample, 56.67% (group 3) refers to the most common MCI form described, while the rest refer to other variants.

According to morphologic appearance, group 1 was designated as narrow/cervically strangled (very convergent), group 2 as intermediate (moderate convergence), and group 3 as wide/stout (little convergence), which can be seen in Fig 2. One of the less frequent forms is more convergent: group 1 (narrow, minor/major mesiodistal ratio of < 0.72). In a well-arranged dental arch, these types would have large interproximal embrasures with broader and higher papillae, which usually show a pronounced scalloped gingiva (Fig 3). More than half of the sample was classified as group 3 (stout, minor/major mesiodistal ratio > 0.83) that displays a flat gingival profile with shorter papillae (Fig 4). Intermediate forms (group 2, minor/major mesiodistal ratio of 0.72 to 0.83) is a less frequent type, but visually could easily be mistaken for another group, and also borderlines groups 1 and 3 (Fig 5). Clinical assessment of dental forms is difficult

Fig 4 *Clinical example of group 3 (wide/stout/little convergence).*

Fig 5 *Clinical example of group 2 (intermediate/moderately convergent).*

and heavily dependent on individual perception, which stresses the importance of GCC as an objective tool in this task.

Additionally, the CC value (commonly referred as the cervical convexity) shows statistical significance between groups, and may be used to complete form definition. However, its direct clinical assessment can be difficult, in particular when the CC is covered by gingival tissue. Crown height (in this study, CL) could be regarded as a confusing factor since it has shown no statistical significance between groups; in a clinical situation, it is easy to be misguided, as could be seen in the examples (see Figs 3 to 5).

Conclusions

The results suggest that MCI morphology can be properly assessed through quantifiable methods. The grade of cervical convergence is a stable and useful value in identifying MCI forms, not only in extreme cases but in all of its variant forms. The minor/major mesiodistal ratio is a quantifiable definition of dental forms based on characteristics that are not modified because of the position of the gingival margin or incisal wear. The use of this anatomical proportion is simple and easily reproducible, but the relationship with other periodontal characteristics, such us gingival thickness, would require further re-search. The clinical relevance of the findings is oriented to the search for associations between dental forms and periodontal biotypes. In addition, the GCC may help clinicians assess tooth shape more accurately before performing restorative, orthodontic, or surgical treatments.

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