Comparison of the anatomic crown width/length ratios of unworn and worn maxillary teeth in Asian and white subjects

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Statement of problem. Various aspects of anatomic tooth dimensions have been examined in a number of studies where data are primarily based on the measurements obtained from white subjects. Additional factors such as ethnicity should be considered to produce a more comprehensive analysis.

Purpose. The purpose of this study is to compare the anatomic crown dimensions of extracted maxillary teeth in Asian and white populations.

Material and methods. The width/length ratio (%) was calculated with standardized digital images of extracted maxillary anterior teeth from 157 Asian and 142 white subjects. Statistical analysis was performed to compare the 4 tooth groups (central incisiors, lateral incisiors, canines, and premolars) of the 2 ethnicities. The distribution of the outcome variables were examined for normality with the Kolmigorov-Smirnov test. Independent sample *t* tests were used to examine differences in outcomes in Asian and white subjects.

Results. There was a significant difference ($P<.05$) in the width/length ratios of all maxillary anterior teeth in Asian and white subjects. In addition, there was a significant difference in the width of unworn central incisors and the length of worn lateral incisors and canines.

Conclusions. Ethnicity influences width/length ratios for all 4 anterior maxillary teeth. Anterior maxillary teeth in Asian subjects appear to be more slender when compared with those in white subjects. (J Prosthet Dent 2012;107:11-16)

CLINICAL IMPLICATIONS
These results can be clinically applied when planning implant therapies, restorative procedures, and periodontal surgeries involving the maxillary esthetic zone. By using the width values, which have been shown to remain mostly unchanged, the proposed average width/length ratios can be calculated for each ethnic group and thus may accurately determine the correct tooth length in the esthetic zone.

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Optimal esthetic outcomes in prosthodontics and restorative dentistry call for a precise knowledge of natural oral esthetics. A checklist for esthetic restorative success was first presented in 1979[1] and updated by Magne and Belser in 2002.[2] This checklist encompassed objective and subjective parameters, including dental esthetics, gingival esthetics, and the more subjective esthetic integration into the frame of the smile, face, and, more generally, the individual. The relative dimensions of anterior teeth are considered important objective criteria within the esthetic checklist because of their clinical relevance. In this context, mesiocervical and incisocervical tooth dimensions have been available since 1902,[3] and the proportions of anterior teeth since 1973.[4] However, esthetically pleasing parameters may vary with different ethnicities. In this context, the definition of ideal tooth dimensions remains a challenge because of individual variations and proximal/incisal tooth wear.

Recently, the crown width/length ratios of normal clinical crowns have been studied in white subjects.[5,6] In 2003, Magne et al[6] conducted a study with the digital images of the extracted maxillary teeth of white subjects, demonstrating that the crown width/length ratio in white subjects was 78% for unworn central incisors, 73% for unworn lateral incisors, and 73% for unworn canines. This same protocol was used by Marcuschamer et al[7] to measure the maxillary anterior teeth of Asian subjects. Here, the mean width to length ratio was 72% for unworn central incisors, 67% for unworn lateral incisors, and 67% for unworn canines.

When planning restorative procedures in the esthetic zone, the clinician should ideally consider the issue of ethnicity.[8] Some studies of tooth size and tooth morphology in varying populations have shown differences both within and between ethnic groups.[9-11] Bailit[8] emphasized the importance of clinicians considering these minor variations in dental traits among population types, as

these differences could influence the prosthodontic outcome. However, to date, the authors have identified no comparative analysis of width/length ratios among ethnic groups.

The purpose of this study was to compare the anatomic crown width, length, and width/length ratios of 4 maxillary tooth groups (central incisors, lateral incisors, canines, and first premolars) of the maxillary dentition in white and Asian subjects. The null hypothesis was that there were no differences in mean length, width, or width/length ratio of worn or unworn extracted maxillary central incisors, lateral incisors, canines, and premolars between Asian or white subjects.

MATERIAL AND METHODS

The Institutional Review Board at Tufts University School of Dental Medicine approved the study protocol. For the Asian subjects group, 264 extracted maxillary anterior teeth (first premolar to first premolar) were examined at Kyushu University School of Dentistry, Fukuoka, Japan. This group included 91 central incisors, 76 lateral incisors, 54 canines, and 43 first premolars. For this study, population identifiers such as race and tooth type were recorded. The same parameters were recorded for the white subjects group at the School of Dental Medicine, University of Geneva, Switzerland. This group included 146 extracted maxillary anterior teeth (44 central incisors, 41 lateral incisors, 38 canines, and 23 first premolars). Power analysis (0.99) determined the sample size was optimal to reject the null hypothesis. After scaling and ultrasonic cleaning, the teeth were grouped according to their type and divided into unworn and worn subgroups. The criterion for this selection was the presence of incisal wear facets along with/without well-defined dentin exposure. A view of the incisal edges of central incisors by means of tangential light was used to show incisal edge configuration in order to divide the teeth into those with attrition and those without. Because

of the state of preservation, all premolars were allocated to the unworn group. Standardized photographs of the buccal surface were made by using a digital camera (Canon EOS 30D; Tokyo, Japan and Fujifilm Finepix S1 Pro; Fuji Photo Film, Tokyo, Japan) attached to a photographic stand (RT 1; Kaiser, Buchen, Germany). Teeth were positioned visually according to their main axis and recorded to the original magnification of ×1.5, resulting in 264 digital photographs (resolution maintained at 2336 by 3504 pixels and 8-bit grayscale, generating 3.6-megabyte files) for the Asian group, and the same magnification, resulting in 146 digital photographs (resolution maintained at 1536 by 2304 pixels and 8-bit grayscale, generating 3.5-megabyte files) for white subjects. Image-processing programs (Image J; Java-based image processing program developed at the National Institutes of Health, Bethesda, Md for Asian subjects, and Scion Image, developed at the Research Services Branch of the National Institute of Mental Health, Bethesda, Md for white subjects) were used to measure 1) the widest mesiodistal portion, W, (perpendicular to the long axis of the tooth) and 2) the longest apicocoronal distance, L, (parallel to the long axis, between the most apical point of the CEJ and the most incisal point of the anatomic crown) (Fig. 1). Special calibration tools built into the software were used to convert pixels into millimeters. The data were then transferred to a spreadsheet program for mathematical arrangement, including the calculation of the width/length ratio, R.[6]

Comparisons of W, L, and R between the ethnic groups were analyzed statistically for each of the 4 tooth types and for worn and unworn teeth. The distribution of the outcome variables (including length, width, and width/length ratios) were examined for normality with the Kolmigorov-Smirnov test. All data were normally distributed. Independent sample t tests were used to examine differences in outcomes (including
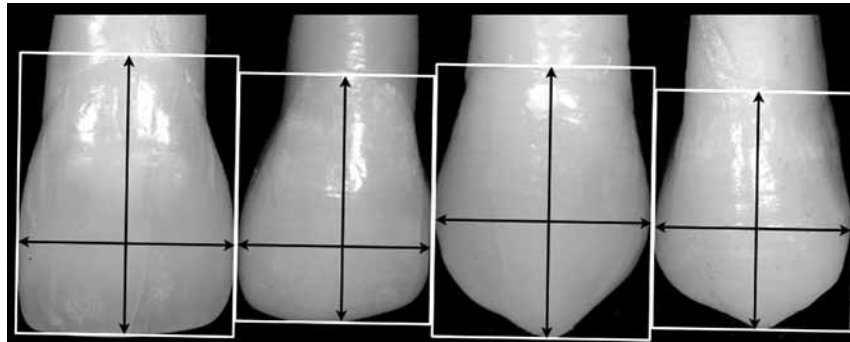
1 Outline of anatomic crowns of maxillary central incisor, lateral incisor, canine, and premolar. Vertical arrows indicate long axes of tooth, indicating length of anatomic crown. Horizontal arrows indicate perpendicular to long axes of tooth in widest portion of anatomic crown, usually correlated to contact points, indicating width of anatomic crown.

TABLE I. The mean values (SD) in mm and range of width, length, and width/length ratio of 4 unworn tooth types for Asian and white groups

| Unworn Dentition	n	Width (mm)	P	Length (mm)	P	W/L Ratio %	P
Central incisors Asian (range)	35	8.63 (0.56) (7.8-9.7)	.003	11.93 (0.81) (10.08-13.24)	.41	0.72 (0.04) (0.65-0.81)	<.001
Central incisors white (range)	18	9.10 (0.62) (8.46-11.07)		11.69 (0.70) (10.70-13.51)		0.78 (0.03) (0.71-0.84)	
Lateral incisors Asian (range)	47	6.99 (0.52) (5.52-8.34)	.59	10.52 (0.75) (8.72-12.79)	<.001	0.67 (0.05) (0.57-0.77)	<.001
Lateral incisors white (range)	30	7.07 (0.76) (5.51-8.22)		9.75 (0.83) (8.19-11.51)		0.73 (0.07) (0.57-0.83)	
Canines Asian (range)	32	7.91 (0.63) (6.64-9.00)	.93	11.83 (0.83) (10.36-13.99)	<.001	0.67 (0.06) (0.57-0.77)	<.001
Canines white (range)	25	7.90 (0.64) (6.80-9.02)		10.83 (0.77) (9.71-12.94)		0.73 (0.06) (0.60-0.82)	
Premolars Asian (range)	43	7.56 (0.46) (6.70-8.71)	.10	8.68 (0.68) (7.62-10.16)	.05	0.87 (0.06) (0.76-0.97)	.04
Premolars white (range)	23	7.84 (0.73) (6.61-8.84)		9.33 (0.94) (7.66-10.45)		0.84 (0.06) (0.65-0.95)	

P<.05 indicates significant difference

width, length, and width/length ratio for central incisors, lateral incisors, canines, and premolars) in Asian and white subjects. All tests were 2-sided and an alpha value of .05 was deemed to be statistically significant.

RESULTS

Width, length, and width/length ratio of unworn teeth for Asian and white subjects are presented in Table I. For the unworn teeth, the W

(P=.003) and R (P=≤.001) values for the central incisors were significantly higher for the white subjects group than for the Asian ones. (Figs. 2-3) This was not the case for the L value, which was not significantly different in
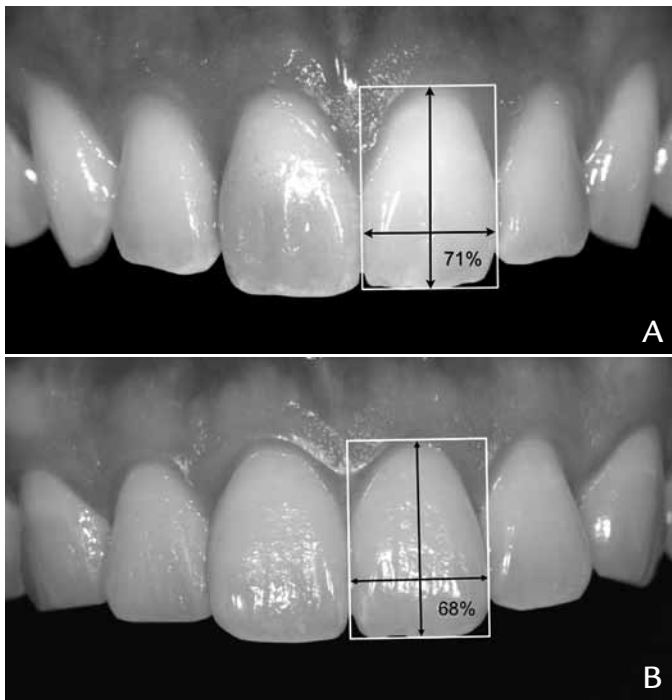
2 A. Maxillary anterior sextant of 2 different Asian subjects with unworn maxillary dentition. Clinical crown of maxillary left central incisor is outlined in white. Vertical arrow indicates long axes of tooth, indicating length of clinical crown. Horizontal arrow indicates perpendicular to the long axes of tooth in widest portion of anatomic crown at level of contact points. Note clinical crown W/L ratio of this tooth is 71% (Fig. 1A) and 68% (Fig. 1B).
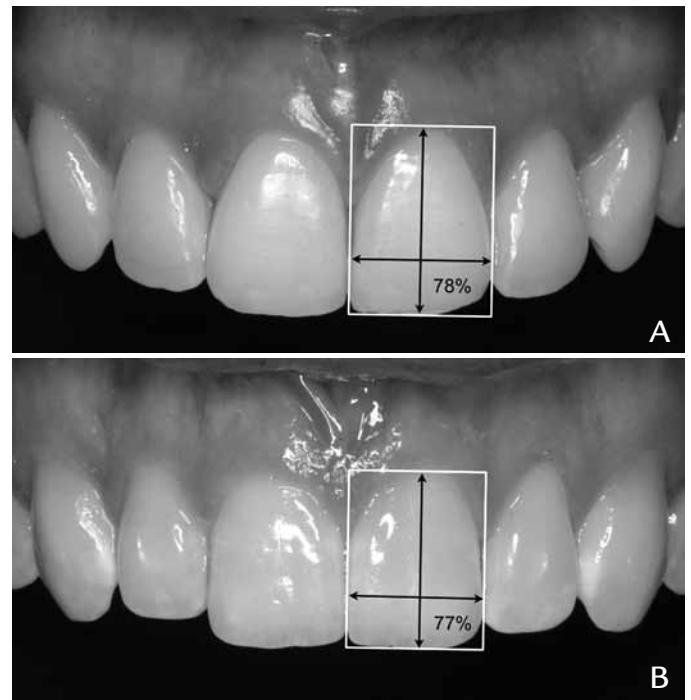
3 Maxillary anterior sextant of 2 different white subjects with unworn dentition. Clinical crown of maxillary left central incisor is outlined in white. Vertical arrow indicates long axes of the tooth, indicating length of clinical crown. Horizontal arrow indicates perpendicular to long axes of tooth in widest portion of anatomic crown at level of contact points. Note clinical crown W/L ratio of this tooth is 78% (Fig. 3A) and 77% (Fig. 3B).

TABLE II. Mean values (SD) in mm and range of width, length, and W/L ratio of worn tooth types in Asian and white groups

Worn Dentition	n	Width (mm)	P	Length (mm)	P	W/L Ratio %	P
Central incisors Asian	56	8.90 (0.49)	.03	11.38 (0.63)	.05	0.78 (0.04)	<.001
(range)		(7.90-10.48)		(10.20-12.91)		(0.70-0.88)	
Central incisors white	26	9.24 (0.66)		10.67 (1.13)		0.87 (0.08)	
(range)		(8.21-10.34)		(8.56-13.42)		(0.74-1.10)	
Lateral incisors Asian	47	7.25 (0.40)	.42	9.72 (0.63)	.18	0.75 (0.06)	.03
(range)		(6.48-7.99)		(8.59-11.15)		(0.63-0.83)	
Lateral incisors white	11	7.38 (0.52)		9.34 (0.80)		0.79 (0.06)	
(range)		(6.43-7.89)		(7.97-11.22)		(0.70-0.87)	
Canines Asian	32	8.10 (0.59)	.83	10.86 (1.07)	.01	0.75 (0.05)	<.001
(range)		(7.07-9.60)		(9.14-13.23)		(0.64-0.86)	
Canines white	13	8.06 (0.74)		9.90 (0.84)		0.81 (0.06)	
(range)		(6.60-8.72)		(8.83-11.77)		(0.72-0.91)	

P<.05 indicates significant difference

either population group. The unworn lateral incisors and canines showed a similar pattern. No significant differences were observed for the W value. However, the L value ($P≤.001$) was higher for the Asian group, and the R value ($P≤.001$) was higher for the white groups. The unworn premolars were significantly different for the R ($P=.04$) value. One interesting finding was the consistently higher R values for the white subjects in the unworn maxillary central, lateral, canine, and premolar tooth groups (Table I). Data comparing the W, L, and R values for worn teeth in both groups are presented in Table II. The central incisor group in the white subjects presented a higher value for the W ($P=.03$) and R ($P≤.001$). Conversely, the L values ($P=.05$) were higher for the Asian group, although this was not statistically significant. There was no significant difference in the W and L values for the lateral incisors. However, the R value was significantly higher ($P=.03$) for the white subjects group. The canine tooth group in Asian and white groups showed differences for the L and R values but not for the W value.

Significant differences were found in the R ($P≤001$ for central incisors and canines and .03 for lateral incisors) values of all worn maxillary anterior teeth. The R value for white subjects was consistently higher than for the Asian group (Table II).

DISCUSSION

The null hypothesis was rejected for the W/L ratio values in all groups. These findings suggest that white individuals may have larger W/L ratios for the maxillary anterior teeth than Asians. These measurements of the anatomic crown proportions could help in the planning of restorative/periodontal treatment. Even though it would appear more relevant to measure clinical crowns, this experimental protocol was designed to use extracted teeth and anatomic crown measurement instead. Width measurements of extracted teeth can be precise, and

therefore, can be used clinically to restore ideal clinical crown dimensions.[6]

Several investigations have been conducted to examine tooth dimension and proportion. However, most of these studies were conducted in white populations.[5,6,8]

Since the 1990s, crown width and length ratio has been considered the most important and valuable factor for achieving an esthetic outcome in the maxillary anterior dentition. This belief was based mostly on data from white subjects. Recently, however, tooth dimensions and width/length ratios for the Asian population have been reported by Marcuschamer et al,[7] and this evidence has allowed for a homogeneous comparison between the 2 ethnic groups.

In the current study, the anatomic crown width/length ratios of unworn and worn maxillary teeth in Asian and white subjects were examined. While specific ethnicity can be used to subcategorize the Asian and the white subject groups, the study population described in this study was assessed as the primary ethnic group. Ideally, specific ethnic criteria within each group, including the family tree, should be used for a more detailed assessment of the differences in dental anatomy. However, this information was not available at the time of sample collection.

In this study, teeth were further divided into unworn and worn dentition to evaluate whether the width and height of maxillary anterior teeth were influenced by attrition. As a result, width measurements were, logically, not influenced by the degree of incisal wear.[6,7] Therefore, the normally preserved tooth width can be used to calculate the appropriate restorative tooth length with the ratio values presented in this study. One of the limitations of this investigation is the small number of identifiers for these populations; only ethnicity and tooth type were described. In this context, further investigation would help clarify whether other parameters such as age, height, and weight play a specific

role in the anatomic configuration of the anterior maxillary teeth.

The comparison of crown width/length ratios in Asian and white subjects revealed a significant difference ($P<.05$) in all maxillary anterior teeth, including premolars. This result suggests that ethnicity should be considered in the prosthodontic/restorative treatment of the maxillary anterior area. In this context, a differential approach using width/length ratio values for both ethnic groups should be used to restore the maxillary anterior sextant.

Previously, interethnic comparisons of maxillary tooth length/width ratios have not been considered. Muller and Eger[12] evaluated the relationship between the masticatory mucosa and periodontal phenotype in whites and Asians by classifying subjects into 3 categories according to gingival thickness and tooth form. Seventy-five percent of individuals were categorized as having a relatively thin and narrow band of gingiva and rather slender tooth form. In contrast, about 21% of the subjects examined presented with thicker and wider gingiva at the maxillary anterior teeth. More importantly, however, data presented in this study demonstrated that the central incisors of Asian subjects seemed to be narrower and more slender than those of white subjects. This result implies that the Asian population might have a thinner biotype than the white population. Further investigation that compares the clinical data regarding biotype and tooth form/shape may be necessary.

CONCLUSIONS

Based on the results of this study, the following conclusions were drawn:

1. Width/length ratios showed significant differences in all 4 anterior unworn maxillary tooth groups in the 2 ethnic groups. The anterior maxillary teeth of Asian subjects appear to have a more slender shape than those of white subjects.

2. With regard to the width of the maxillary anterior teeth in both

ethnicities, only the central incisors showed any statistical difference.

3. The length of the maxillary anterior teeth, lateral incisors, canines, and premolars showed significant difference in the 2 ethnicities.

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