Dentition and Occlusion Development in African American Children: Mesiodistal Crown Diameters and Tooth-size Ratios of Primary Teeth

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Abstract

Purpose: The aim of this study was to evaluate the mesiodistal primary tooth size diameter and posterior sagittal tooth-size ratio in an African American population and compare to existing African American and European American norms.
Methods: A sample of 1,124 African American children, 564 males and 560 females, was used to record crown size diameters employing indirect (cast) and direct (intraoral) measurement techniques.
Results: African American males showed larger crown diameters than African American females for each of the 5 classes of primary teeth (α=0.05 level). Sexual dimorphism averaged 3.5% in the maxilla and 3.2% in the mandible. When inter-racial primary crown size comparisons were made between African American and European American children, African American males showed larger mean crown diameters for each class of primary teeth compared to European American males. The inter-racial comparisons in crown diameters of females showed fewer statistically significant differences in primary teeth classes. When crown size comparisons of the primary dentition's posterior segments were made, African American males and females showed a larger primary posterior sagittal tooth-size-ratio compared to European American children.
Conclusions: While intra- and inter-racial sex differences exist in the primary teeth of African American and European American children, with few exceptions, the mesiodistal crown size differences and sexual dimorphism appear to be larger for the African American population. African American children show a larger primary posterior sagittal tooth-size ratio (0.96) compared to European American children (0.94). (Pediatr Dent 2005;27:121-128)

Keywords: primary teeth, mesiodistal crown diameters, tooth size, African American, occlusion, child

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A preponderance of epidemiological studies[1-4] that describe the sagittal arrangement of the jaws (dental arches) suggest certain racial differences in the distribution of the occlusal relationships of human dentitions. Based on Angle's classification of occlusion, European American children show a higher incidence of Class II malocclusions[1] and lower incidence of Class I and III malocclusions[2-4] compared to African American children. Little investigation or explanation has been offered as to the controlling and contributing factors that may shed light on the observed population differences in occlusal distribution.

Classification of occlusion in the primary dentition is conventionally assigned based on the the sagittal relationship of the distal surfaces of the primary second molars (flush terminal plane, mesial step, and distal step). Classification of occlusion in the permanent dentition, as defined by Angle, is based upon the sagittal buccal cusp surface relationship of the permanent first molars (mesiobuccal cusp of the maxillary first molar occluding in the mesiobuccal grove of the mandibular first molar, or, anteroposterior variations of same).

Investigations related to transitional occlusal development and forecasting have focused on correlations between the primary second molars' terminal plane relationship and the permanent first molar's occlusal eruption position. The operating hypothesis is that the type of terminal plane arrangement observed in the primary dentition will either advantage or disadvantage certain occlusal relationship outcomes of the erupting permanent first molar.

Moyers[5] has described the "usual and normal" primary terminal plane in European American children as a flush terminal plane. Friel[6] has suggested that the coincidental nature of the flush terminal plane is due to the difference in tooth size

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Table 1. Statistically Determined Sample Size, Calculated (N) vs Actually Measured Sample Size (N) of the 5 Classes of Primary Teeth in African American Children* †

Male				
Tooth	Maxillary		Mandibular	
Class	Calculated (N)	Measured (N)	Calculated (N)	Measured (N)
pi1	361	362	223	234
pi2	210	416	171	312
pc	375	836	237	718
pm1	562	808	524	780
pm2	932	924	513	940
Female				
Tooth	Maxillary		Mandibular	
Class	Calculated (N)	Measured (N)	Calculated (N)	Measured (N)
pi1	437	438	120	202
pi2	178	394	161	296
pc	234	836	248	708
pm1	477	808	207	774
pm2	935	936	314	898

*pi=primary incisors; pc=primary cuspids; pm=primary molars.
†Statistical computation of the calculated (N) sample size was performed with the software program Statmost 2.01 for Windows, Datamost Corp, Salt Lake City, Utah. The measured (N) reflects all antimered pairs of teeth.

between the primary maxillary and mandibular second molars, with the latter being wider mesiodistally. Similar studies of primary tooth size and tooth-size ratios are all but nonexistant for African American children. A first step in learning about the development of this population's dentition and occlusion is the determination of tooth size and tooth-size ratios.

The purpose of this study was to evaluate the mesiodistal primary tooth size diameter and posterior sagittal tooth-size ratio in an African American population and make a comparison to existing African American and European American norms.

Methods

Sample size, bias, and statistical derivation

A convenience sample of 1,124 African American children, 564 males and 560 females, was examined in this study. A clinical records review suggested that:

1. The sample was heavily biased toward children of low socioeconomic status.
2. Data on body weight at birth was unavailable.

To obtain a sample size adequate to make valid statistical estimates of population means and proportions for the 5 classes of primary teeth (incisors, laterals, cuspids, first molars, and second molars), the data derived by Vaughn and Harris[7] were treated as a pilot study. Using their reported standard deviations per tooth class at a 95% confidence level, a statistically derived theoretical sample size (N) per tooth class was calculated and recorded (Table 1). The actual sample size obtained and measured in this study is also shown in Table 1.

Table 2. Null Hypothesis Testing for Intraracial Differences in Mesiodistal (MD) Crown Diameters (CD) of Primary Teeth Using Different Sample Sources of European American Children*

Tooth class and source	N	Sex	Mean MD-CD±SD (mm)	*t* value	*P* value
			Maxilla		
pi1					
Michigan†	166	M	6.41±0.43	-2.31	.022
Moorrees‡	64		6.55±0.36		
Michigan	169	F	6.48±0.43	.65	.516
Moorrees	69		6.44±0.43		
pi2					
Michigan	189	M	5.26±0.37	-1.11	.27
Moorrees	64		5.32±0.39		
Michigan	175	F	5.29±0.43	1.17	.244
Moorrees	69		5.23±0.33		
pc					
Michigan	212	M	6.76±0.34	-2.45	.015
Moorrees	65		6.88±0.36		
Michigan	194	F	6.63±0.35	-.82	.416
Moorrees	69		6.67±0.35		
pm1					
Michigan	214	M	6.74±0.49	-6.54	.001
Moorrees	64		7.12±0.38		
Michigan	195	F	6.61±0.49	-6.07	.001
Moorrees	68		6.95±0.36		
pm2					
Michigan	213	M	8.84±0.53	-3.25	.001
Moorrees	63		9.08±0.46		
Michigan	196	F	8.74±0.47	-1.45	.15
Moorrees	68		8.84±0.55		

Table 2 continued on page 123

Measurement method

Plaster dental casts, made from alginate impressions, were used to record tooth size. The tooth selection criteria excluded primary teeth with the following characteristics:

1. Class II caries or dental restorations on the approximal surfaces of molars, and Class III caries or dental

Table 2 continued					
Tooth class and source	N	Sex	Mean MD-CD ±SD (mm)	*t* value	*P* value
			Mandible		
pi1					
Michigan	144	M	4.06±0.35	-0.42	.692
Moorees	64		4.08±0.30		
Michigan	144	F	4.10±0.31	2.66	.008
Moorrees	68		3.98±0.30		
pi2					
Michigan	182	M	4.64±0.43	-1.69	.093
Moorrees	65		4.74±0.35		
Michigan	171	F	4.68±0.40	.88	.378
Moorrees	69		4.63±0.39		
pc					
Michigan	213	M	5.84±0.33	-1.72	.086
Moorrees	65		5.92±0.32		
Michigan	193	F	5.82±0.651	1.27	.202
Moorrees	68		5.74±0.35		
pm1					
Michigan	209	M	7.82±0.47	0.31	.759
Moorrees	65		7.80±0.42		
Michigan	195	F	7.71±0.46	1.12	.264
Moorrees	69		7.65±0.35		
pm2					
Michigan	214	M	9.90±0.52	.94	.348
Moorrees	63		9.83±0.52		
Michigan	196	F	9.73±0.48	1.33	.184
Moorrees	69		9.64±0.49		

*pi=primary incisors; pc=primary cuspids; pm=primary molars.
†Michigan=data of Moyers et al.[9]
‡Moorrees=data of Moorrees et al.[8]

Table 3. Null Hypothesis Testing for Intraracial Differences in Mesiodistal (MD) Crown Diameters (CD) of Primary Teeth Using Different Sample Sources of African American Children*

Tooth class and source	N	Sex	Mean MD-CD±SD (mm)	*t* value	*P* value
			Maxilla		
pi1					
Howard†	282	M	6.75±0.46	-.87	.383
Vaughn‡	28		6.83±0.48		
Howard	280	F	6.54±0.43	-1.87	.062
Vaughn	34		6.69±0.53		
pi2					
Howard	416	M	5.48±0.38	-.6	.549
Vaughn	35		5.52±0.37		
Howard	394	F	5.30±0.41	-2.77	.006
Vaughn	38		5.49±0.34		
pc					
Howard	840	M	6.97±0.41	-.78	.436
Vaughn	44		7.02±0.49		
Howard	836	F	6.74±0.42	-.78	.435
Vaughn	45		6.79±0.39		
pm1					
Howard	808	M	7.51±0.50	-2.49	.017
Vaughn	43		7.70±0.61		
Howard	808	F	7.21±0.53	-4.54	.001
Vaughn	43		7.60±0.55		
pm2					
Howard	924	M	9.21±0.54	1.15	.256
Vaughn	42		9.07±0.78		
Howard	936	F	8.87±0.55	-1.26	.214
Vaughn	44		9.02±0.78		

Table 3 continued on page 124

restorations on the approximal surfaces of incisors and cuspids;
2. congenital dental anomalies and defects;
3. a tooth class where only 1 antimere was present and the other missing on the cast;
4. cast defects which placed into question the measurement's accuracy.

Each primary tooth's mesiodistal crown diameter was obtained by measuring the greatest distance between the contact points on its approximal surfaces, as described by Moorrees,[8] using a Mitutoyo sliding digital caliper (Mitutoyo Corporation, Tokyo, Japan), with a calibrated instrument error of 0.2 mm. The sliding caliper's measuring beaks were modified (tapered) to facilitate easier entry into the embrasure between the teeth at the contact point. The vernier scale read to the nearest 0.1 mm.

An assessment of the systematic error in measuring the mesiodistal crown diameters of the 5 classes of deciduous teeth was performed by the author. A sample of 576 sets of single determinations was used and expressed as standard deviations of the differences. The measurement error for the 5 classes ranged from 0.07 mm (mandibular incisor) to 0.21 mm (maxillary second molar). Statistical analysis of the data on mesiodistal crown dimension was based on the combined average diameter of the teeth on the right and left side of each dental cast or dental arch,

Table 3 continued

Tooth class and source	N	Sex	Mean MD-CD±SD (mm)	*t* value	*P* value
Mandible					
pi1					
Howard	234	M	4.20±0.38	-.90	.367
Vaughn	20		4.28±0.38		
Howard	202	F	4.08±0.41	0	1.00
Vaughn	24		4.08±0.27		
pi2					
Howard	312	M	4.70±0.39	-1.34	.182
Vaughn	29		4.80±0.33		
Howard	296	F	4.60±0.41	0.14	.892
Vaughn	33		4.59±0.32		
pc					
Howard	718	M	6.08±0.37	-1.21	.225
Vaughn	44		6.15±0.39		
Howard	708	F	5.86±0.38	-1.67	.095
Vaughn	43		5.96±0.40		
pm1					
Howard	780	M	8.19±0.50	-2.66	.008
Vaughn	39		8.41±0.58		
Howard	774	F	7.91±0.54	-4.68	.001
Vaughn	44		8.18±0.36		
pm2					
Howard	938	M	10.32±0.55	-2.3	.022
Vaughn	38		10.53±0.57		
Howard	910	F	9.94±0.57	-3.59	.001
Vaughn	45		10.25±0.45		

*pi=primary incisors; pc=primary cuspids; pm=primary molars.
†Howard=Howard University (location of this study)
‡Vaughn=Vaughn et al.[7]

providing an arithmetic mean for the 5 tooth classes of the respective dental arches.

Direct (intraoral) vs indirect (dental cast) measurement techniques

A comparison of different tooth measuring techniques was carried out to reduce the labor and cost of extra dental cast preparations needed to fulfill the statistically required sample size of maxillary central incisors (male and female).

The comparison of the techniques (direct vs indirect) was performed by the same investigator using sample subsets of: (1) primary maxillary central incisors (N=68); (2) mandibular central incisors (N=68); (3) maxillary lateral incisors (N=72); (4) mandibular lateral incisors (N=74); (5) maxillary cuspids (N=74); and (6) mandibular cuspids (N=76). These subsets were divided equally by sex. The total number of teeth measured for comparison purposes was 460. Data tabulation and calculation were performed by tooth class without sex differentiation. The average mean difference between the direct and indirect techniques was 0.020 mm for maxillary teeth and 0.022 mm for mandibular teeth. Statistically, no difference between mean values of the direct vs indirect technique was found for any tooth class measured.

The indirect technique (dental cast) was used to establish reference norms for all classes of primary teeth, except for the maxillary central incisors (male and female). Seventy-eight percent of the male and 64% of the female maxillary incisor sample size requirement was accomplished using the indirect technique. The remaining (22%) male and (36%) female maxillary incisor requirements were completed by use of the direct (intraoral) technique.

Comparisons of primary teeth diameters for intra-racial- and inter-racial populations

Because of the underlying alternative null hypothesis regarding reported inter-racial differences in occlusal distributions, it was felt that an assessment of the status of intra-racial group differences in primary tooth size should be investigated. The selection of the specific intra-racial European American databases (Moyers et al[9] vs Moorrees et al[10]) for comparison was not difficult to find. This was not the case with respect to available reported intra-racial African American databases. The only study found was by Vaughn and Harris[7]; thus, their data were used to make intra-racial comparisons with this study's results.

As for the inter-racial comparisons, this study's odontometric results were compared with standards (mean values) established for European American children, as reported by Moyers et al.[9] The selection of the Moyers et al[9] data was made based on the larger sample size of primary teeth.

Comparisons of posterior sagittal primary tooth-size ratios

The posterior sagittal primary tooth-size ratios were established for each racial population (African American vs European American) by dividing the sum of the mean crown diameters of the primary maxillary cuspid, first, and second molars by the sum of the mandibular primary cuspids, first, and second molars. The mean tooth size values, as reported by Moyers et al,[9] were used for comparative purposes.

Statistical computations

The quantitative data generated in this study were assessed, by gender, for normality of distribution using Kolmogorov-Smirnov Goodness of Fit Test.

Descriptive statistics and standard error of the mean (SEM), by sex for mesiodistal crown diameter were determined. Statistical differences between mesiodistal crown diameter, by sex, and by side were determined using the student's *t* test. Sex dimorphism was assessed using a 2-sample independent group *t* test. Paired *t* test was used in the direct vs indirect tooth measuring technique

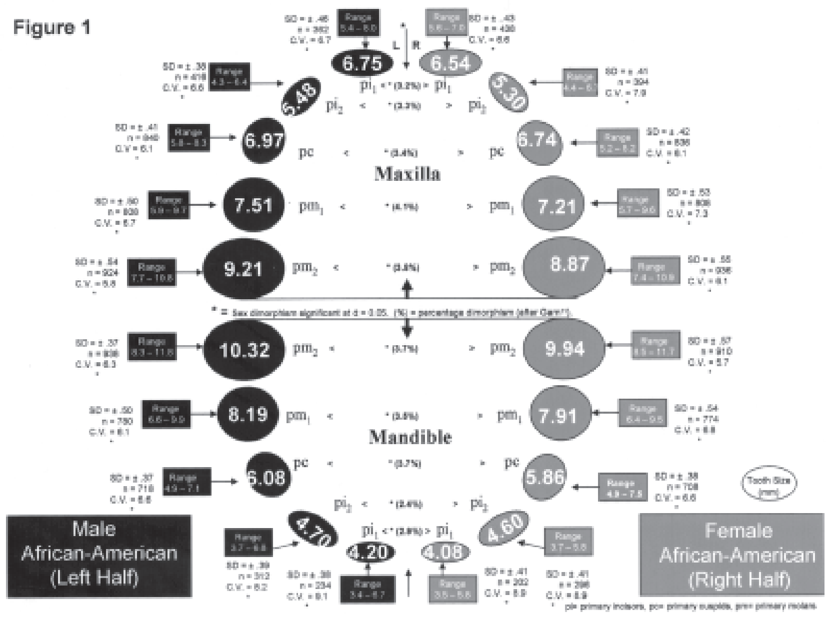

Figure 1. Descriptive statistics and percentage sexual dimorphism of the mesiodistal crown diameters of primary teeth in children of African American descent.

Teeth	African (Male) (mm)	*European (Male) (mm)	African (Female) (mm)	*European (Female) (mm)
Maxillary pc + pm_1 + pm_2	23.69	22.34	22.82	21.98
Mandibular pc + pm_1 + pm_2	24.59	23.56	23.71	23.26
Max/Mand: Ratios	0.96	0.94	0.96	0.94

*European-American tooth measurements of Moyers, et al[9], pc= primary cuspids, pm= primary molars

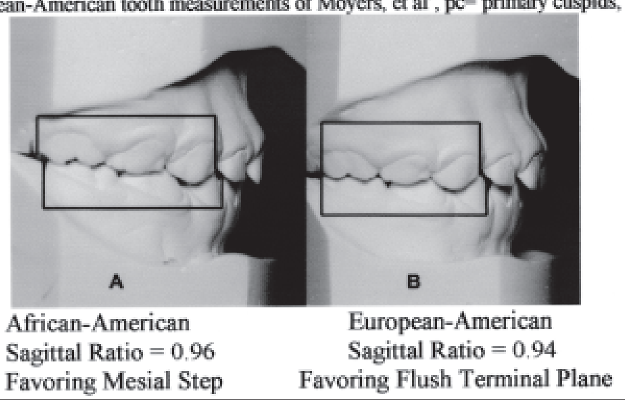

Figure 2. Odontometric comparison of posterior sagittal ratios of the combined mesiodistal crown diameters of the primary maxillary and mandibular cuspids and first and second molars of African American vs European American children.

comparisons. All statistical data computations were performed using the Winks Software (Texa-soft Inc, Cedar Hill, Tex). The percent sex dimorphism was calculated using the formula in Garn et al[11]:

$$\% \text{ dimorphism} = \frac{[X\text{male} - X\text{female}]}{X\text{female}} \times 100$$

Research involving human subjects

Where applicable, this investigation was governed by the guidelines of the Internal Review Board of Howard University.

Results

The odontometric findings on mesiodistal crown diameters of primary teeth of African American children and the percent sex dimorphism are summarized in Figure 1. Inter-racial and intra-racial comparisons of mesiodistal crown diameters of primary teeth are presented in Figures 2 through 4 and Tables 2 and 3, respectively. The results were analyzed following the outline established in the Methods section.

Mesiodistal crown diameters comparing male and female African American children

The average mesiodistal crown diameter for each primary tooth class was larger in males compared to females (Figure 1; *P*=.001). The average magnitude of the sex difference was 3.5% for the maxillary arch and 3.2% for the mandibular arch (Figure 1). The classes of teeth with the largest coefficient of variation (CV), by sex, were the primary mandibular central and lateral incisors (range=8% to 9%). All other classes, maxillary and mandibular, averaged a CV of 7%. The standard error of the mean for each tooth class ranged between 0.02 and 0.04 mm. There were no statistically significant right and left antimere tooth class size differences found for either sex.

Inter-racial comparisons of posterior tooth-size ratios

The mean posterior sagittal dental ratio was 2% larger for both male and female African American children compared to European American children (Figure 2). The primary maxillary first molar, in males and females, made the largest contribution toward this 2% tooth material difference (Figures 2 to 4).

Inter-racial comparisons of primary teeth diameters

When inter-racial comparisons in crown diameters were made, African American males showed larger mean crown diameters for each class of primary teeth (Figure 3). The inter-racial male crown size difference was statistically significant (*P*=.001) for each class of primary teeth except the mandibular lateral incisors (*P*=.113). The inter-racial comparisons in crown diameters of females showed fewer statistically significant differences in primary tooth classes. African American females showed larger (*P*=.001) mean crown diameters of the primary maxillary and mandibular first and second molars, maxillary cuspids, and mandibular lateral incisors. No statistically significant inter-racial female differences were observed for the maxillary central and lateral incisors, mandibular central incisors, and mandibular cuspids (Figure 4).

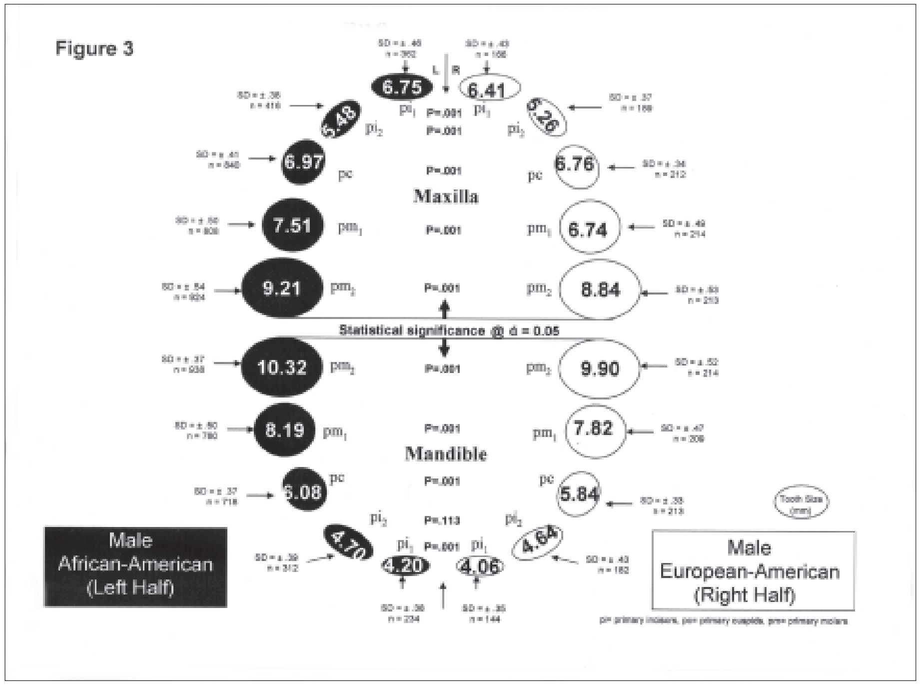

Figure 3. Statistical estimation of size differences in mesidodistal crown diameters of primary teeth between racial populations (African American male vs. European American male.

Statistical analysis of different intra-racial studies of mesiodistal crown diameters

When statistical analyses were applied to different samples (studies) of European American children, statistically significant differences were found for mean diameters of the following classes of primary teeth:

1. maxillary central incisors (*P*=.022), cuspids (*P*=.015), and first and second molars (*P*=.001) in males;
2. the maxillary first molars (*P*=.001) and mandibular central incisors (*P*=.008) in females (Table 2).

When comparisons were made using different samples (studies) of African American children, statistically significant differences were found in the mean diameters of:

1. the primary maxillary first molars (*P*=.017) and mandibular first and second molars (*P*=.008 and *P*=.022, respectively) in males;
2. the maxillary lateral incisors (*P*=.006), maxillary first molars (*P*=.001), and mandibular first and second molars (*P*=.001) in females (Table 3).

Discussion

Studies of the size, sex, and posterior tooth-size ratio differences of primary teeth in African American children are few in number. The only investigation the author found that dealt with the issue at hand was the work of Vaughn and Harris.[7] They reported mesiodistal crown size values for a very limited sample size. It was the statistical review of their reported variance (±SD) per primary tooth class that led to this study's expanded sample size, especially since the aim was to make statistical comparisons to other ethnic population norms that used larger sample sizes (Tables 1 to 3). Because this study also conducted statistical comparisons using the databases of other investigators, some recapitulation of those observations becomes necessary.

The similarities and differences between the findings of this statistically defined sample ("this study") and the reported findings of Vaughn and Harris were compared. The term "both studies" is used to signify the current study and the work of Vaughn and Harris.

With respect to sample biases, "both studies" seemed matched as to ethnicity (African American) and socioeconomic status. Neither study examined the influence of body weight at birth on primary tooth size. The 2 studies contrast sharply with respect to the number of teeth needed to statistically estimate population means based on tooth size variance (±SD) measures (Tables 1 and 3). The mean mesiodistal crown diameters established in this study were smaller for both sexes in every tooth class, except the maxillary second molars in males and the mandibular incisors in females, when contrasted with Vaughn and Harris'[7] values (Table 3). Statistically significant differences were found for the:

1. primary maxillary first molars and mandibular first and second molars in males;
2. maxillary lateral incisors, maxillary first molars, and mandibular first and second molars in females. Similar problems of sampling difficulties can be observed in the reported literature pertaining to European American children[8,9,13] and as demonstrated by the Michigan vs Moorrees data examined in Table 2.

These similar findings raise the question as to which set of tooth-size values are most representative of each ethnic population norm. To address the disparities in results reported in the databases of both ethnic groups, investigators will have to more closely examine the following factors, all of which are reported to affect primary tooth size:

1. statistical definition of sample size;
2. biases which may be associated with body weight at birth[14];
3. nutritional status[16];
4. socioeconomic influences.

Nevertheless, when the results of this study and the work of Vaughn and Harris[7] are compared with European American norms,[8,9] African Americans showed larger mean crown diameters for every class of primary teeth, with the exception of the mandibular central and lateral incisors in females (Tables 2 and 3; Figures 3 and 4). Statistically, when the mean crown diameters of the contrasted ethnic populations were assessed, this study suggested statistically significant differences for every class of primary teeth in males except for the mandibular lateral incisors (Figure 3). In females, statistically significant differences were observed in each class of primary teeth, except for the maxillary central and lateral incisors, and the mandibular central incisors and cuspids (Figure 4).

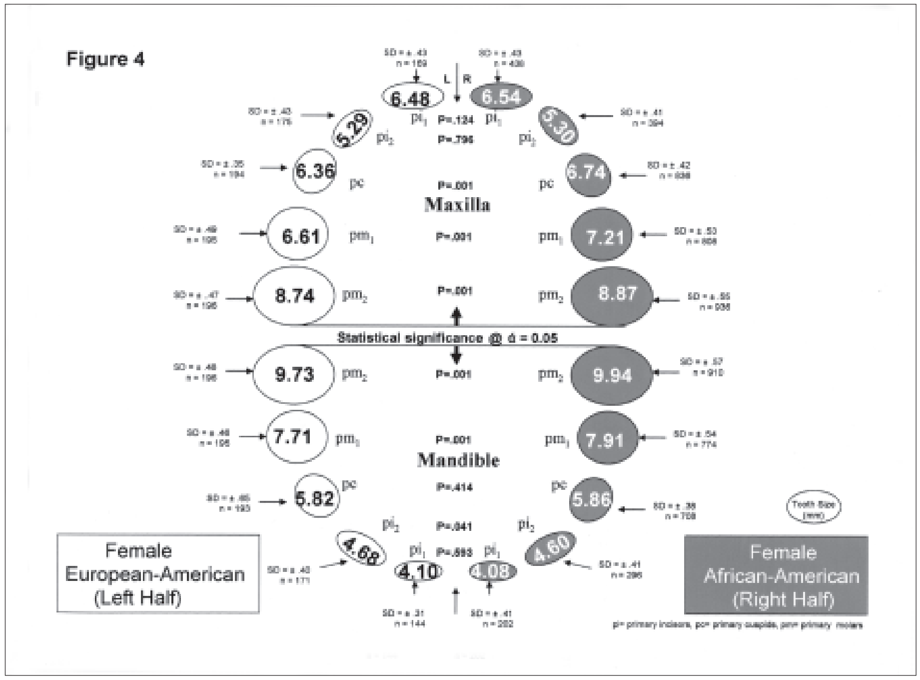

Figure 4. Statistical estimations of size differenes in mesiodistal crown diameters of primary teeth between racial populations (African American female vs. European American female).

Both studies showed a higher level of sex dimorphism than those reported for European American children. This study estimated primary tooth sex differences in African American children at approximately 3%, compared to 1% in European American children (Figure 1).

Both studies disclosed ethnic differences, in both sexes regarding larger posterior tooth-size ratios in African American children compared to European American children (Figure 2).

In summary, with respect to racial differences in the size and sex of primary teeth, this study suggests that, statistically, African American children had, compared to European American children:

1. larger mesiodistal crown diameters and sexual dimorphism of the molars, cuspids, and central incisors in males;
2. molars and lateral incisors in females.

Apart from the data's clinical value in assessing individual patient departure from tooth size norms, the differences in the posterior tooth-size ratios suggest that a flush terminal plane may not be the norm for the African American population. Further investigation of this sample's developmental changes will shed light on this hypothesis.

Conclusions

Based on this study's results, the following conclusions can be made:

1. Within racial groups, males showed larger crown diameters than females for each of the 5 primary teeth classes, with the gender difference being statistically significant at the P=.05 level. The sex differences of normative mesiodistal crown diameters in African American children seemed to be larger than reported findings in European American children.
2. The posterior sagittal tooth-size ratio was larger for African American children (0.96) as compared to European American children (0.94). The primary maxillary first molar made the largest contribution to the 0.96 tooth-size ratio.
3. This investigation also showed statistically significant inter-racial (African American vs The Michigan Data) differences for each class of primary teeth in males and each class of primary teeth in females, except for the maxillary laterals and mandibular central incisors. On average, African American children showed larger mesiodistal crown diameters.

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Abstract of the Scientific Literature

Duration of Restorations in Teeth Injured by Trauma

Unfortunately, dental trauma of the child and young adult is something that we as practicing clinicians are confronted with constantly. In dental traumatology, it is very important to understand which material is best to use and when is the right time to replace the restoration before it loses function and, consequently, leads to complications.

The purpose of this study was a long-term (7-year) clinical evaluation of resin-based composite restorations and original fragment reattachments. The sample size of this study was: (1) 60 patients aged 8 to 18 years who had 90 injured dental crowns; and (2) 20 subjects with crown injuries who served as a validity sample and were treated by different practitioners. Of the 90 selected teeth in the first group, 70 had direct composite restorations and 20 had original fragment reattachments. These teeth were divided according to traditional classifications (Aandreasen, Ellis) and also a new (Spinas-Piroddi) classification, which takes into account material type used in restorations as well as outcomes in long-term follow-up. All restorations were evaluated over a 7-year period. By 3 years postoperative, most restorations needed some form of repair, ranging from a simple polishing to complete replacement. The examiners found that a restoration can be replaced only 3 to 4 times before the tooth shows a severe reduction of its adhesive properties.

Comments: Tooth fracture is a fairly common event, as more sport activities are organized for today's youth. This article should first serve to heighten our awareness in promoting the fact that mouthguards are necessary, with a need to educate parents and patients about their importance. This article reaffirms that when a dental crown injury occurs, composite restorations and original fragment reattachments are the treatment of choice in patients who have not yet achieved their complete dental/skeletal growth. The authors state that resin restorations cannot be used for long-term repair and that prosthetic restoration (crown or veneer) must be used when the subject has completed his/her growth. The repeated injury of a previously traumatized tooth will certainly lessen the chances that a conservative repair using resin will last. Although the prosthetic option eventually may be the case, it would best serve pediatric clinicians to inform parents and patients of this possible outcome and only resort to that step when actually needed. **GM**

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