Volume 21, Number 2-3, 2008 ISSN 1096-9411

Dental Anthropology

A Publication of the Dental Anthropology Association

Dental Anthropology

Volume 21, Number 2-3, 2008

Dental Anthropology is the Official Publication of the Dental Anthropology Association.

Address for Manuscripts

Dr. Edward F. Harris
College of Dentistry, University of Tennessee
870 Union Avenue, Memphis, TN 38163 U.S.A.
E-mail address: eharris@utmem.edu

Address for Book Reviews

Dr. Greg C. Nelson
Department of Anthropology, University of Oregon
Condon Hall, Eugene, Oregon 97403 U.S.A.
E-mail address: gcnelson@oregon.uoregon.edu

Published at

Craniofacial Biology Laboratory, Department of Orthodontics
College of Dentistry, The Health Science Center
University of Tennessee, Memphis, TN 38163 U.S.A.

Deciduous Dental Morphological Diversity in Contemporary Colombian Ethnic Groups

Miguel Eduardo Delgado-Burbano*

División Antropología, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, La Plata 1900, Buenos Aires, Argentina

ABSTRACT: Biocultural diversity of contemporary South American populations has not been studied extensively, therefore delineating some of the patterns of phenotypic variation may be useful for understanding their ongoing evolution. Thirty-seven deciduous dental nonmetric traits were scored on 200 dental casts that were obtained from four contemporary Colombian ethnic groups with different ancestry. Inter-group affinities were assessed by means of a principal component analysis based on trait frequencies. African-American Colombian groups share several dental morphological affinities with other New World African derived populations as well as with Sub-Saharan African dental samples. Colombian Amerindians have a relative affinity with prehistoric Native North American samples, but a clear association with living North American Indians and recent Northeast Asian Sinodont populations was not evident. The biologically admixed group or "Mestizo" has a more complicated pattern of phenotypic relationships, with an African and an Amerindian but not an evident European component. From an evolutionary point of view, gene flow probably is the most important factor that changed the original gene pool through time. These groups have a complex landscape of biocultural variation reflected by their different microevolutionary histories. *Dental Anthropology* 2008;21(2):33-45.

Discontinuous variation in the permanent dentition of modern *Homo sapiens* has been systematically studied from a worldwide level (Scott and Turner, 1997). In contrast, relatively little is known about modern human evolution as depicted in the primary dentition.

Several characters in the deciduous dentition are evolutionarily conservative and have deep phylogenetic and ontogenetic stability in comparison to some traits in the permanent dentition (Edgar and Lease, 2007). Moreover, the early development of deciduous dentition *in utero* allows less external perturbations (Smith, 1978; Smith *et al*., 1987). However, some aspects of the deciduous dentition's evolutionary dynamics are not well known, and its use for the study of human evolution is scarce (Kitagawa, 2000; Sciulli, 1998; Smith, 1978; Grine, 1984; Lukacs and Walimbe, 1984; Lease, 2003; Lease and Sciulli, 2005; Delgado-Burbano, 2007).

Although phenotypic characters shown indirectly genetic relationships and environmental factors may affect the underlying genotype, dental nonmetric traits are reliable skeletal characters since they are strongly controlled by polygenic systems and present high heritability values (*e.g*., Townsend and Martín, 1992; Nichol, 1989).

Several investigations provide information about deciduous nonmetric variation from a local scale in several human groups from Asia and the Pacific (Hanihara, 1956ab, 1961, 1963, 1965, 1966; Hanihara and Minamidate, 1965; Sasaki and Kanasawa, 1998; Kitagawa, 2000), Africa (Grine, 1984, 1986, 1990; Lease, 2003), India (Lukacs and Walimbe, 1984; Lukacs and Hemphill, 1991), Europe (Lease, 2003; JØrgensen, 1956), Near East (Smith, 1978; Smith *et al*., 1987; Moskona *et al*., 1998), Australia (Townsend and Brown, 1981; Townsend *et al*., 1986, 1990) and North America (Sciulli, 1977, 1990, 1998, Tocheri, 2002; Ullinger, 2003; Lease, 2003; Lease and Sciulli, 2005; Edgar and Lease, 2007). Surprisingly, past and present South American populations have received little attention (Delgado-Burbano, 2007).

Although the current use of molecular variants (*i.e*., mtDNA, Y chromosome and autosomal markers) in the study of population history and biological variability of modern human populations is very popular, studies based on phenotypic variation continue to play an important role. The study of phenotypic diversity can help us understand the evolution and biocultural variation of the contemporary communities that today inhabit South America and to obtain a more complete landscape of the dynamics that configure their gene pool. The aims of the present research are to (1) characterize some Colombian communities through their deciduous dental variation, (2) assess this diversity in a regional context, and (3) suggest interpretations of their population history, affinities and microevolution.

---

*Correspondence to: Miguel Eduardo Delgado-Burbano, División de Antropología. Facultad de Ciencias Naturales y Museo. Universidad Nacional de La Plata. Paseo del Bosque s/n. La Plata 1900, Buenos Aires, Argentina.
E-mail: medelgado@fcnym.unlp.edu.ar

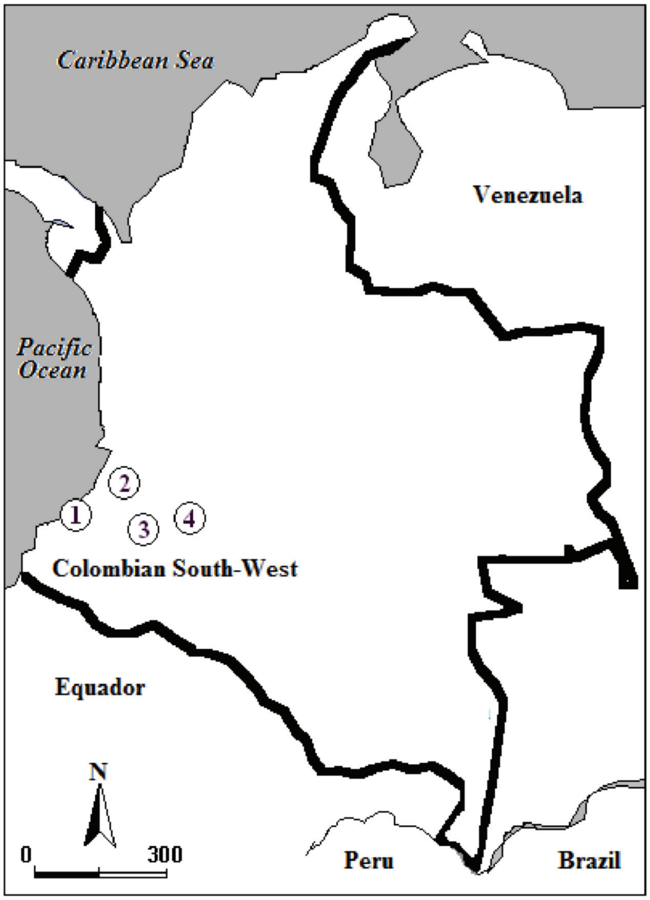

Fig. 1. Map of Colombia showing the geographic location of the populations studied: 1 Guapi, 2 Villarica, 3 Popayán, and 4 Silvia. The scale is in kilometers.

MATERIALS AND METHODS

Study Subjects

Dental casts (n = 200) were collected and analyzed from four communities with different ethnic ancestry located in the southwest of Colombia (Fig. 1). Sex distribution and sample size for the groups are presented in Table 1. Sixty-eight dental models are from Afro-Colombian individuals of the Guapi community in the Colombian Pacific Coast (Pacific Basin). This group inhabits a rural settlement and their subsistence system is based on agriculture, trade and fishing. Nineteen dental casts were obtained from Villarica (Cauca municipality [inland]). This community is a New World African descendent population. Their subsistence system is based on agriculture and sugar cane farming. Their history is related to the distribution of African slaves in farms and sugar mills around the Cauca Valley region. These communities are isolated towns whose inhabitants are of African ancestry (> 90%) with low levels of admixture. Another 56 dental casts were obtained from the Amerindian group Guambiano that inhabits the settlement of Silvia in the Department of Cauca, Colombia. Silvia is a rural settlement characteristic of the highland Amerindian populations of the South American Andes. Guambiano language belongs to Coconucan-Barbacoan family, which belongs to the Chibchan-Paezan or Macro-Chibchan family characteristic of highlands of Colombian southwest and Ecuador (Ethnolgue, 2001). Their subsistence system is based on agricultural activities. Interestingly, according to their mating customs, we expect low rates of European and/or African admixture (Pachón, 1996). The last 57 dental casts were obtained from individuals from Popayán city. This group is known as "Mestizo" (*i.e.*, genetically admixed). Latin American urban populations like Popayán are usually trihybrid (Sans, 2000), with a gene pool composed of varying frequencies of European and Native-American genes, although some African admixture is also expected.

The age and sex of each individual was recorded at the time of casting. The greatest portion of subjects examined in this study are children between 3 and 11 years of age. Only teeth unaffected by wear, pathology, or casting error were included in the analyses. The individual count method was used to record the incidence of trait absence contrasted with all degrees of trait expression (Scott, 1980).

Nonmetric Traits

Thirty-seven deciduous crown nonmetric traits (19 maxillary and 18 mandibular) were scored following suggestions from several authors (Hanihara, 1961, 1963; Sciulli, 1998; Grine, 1986; Turner *et al.*, 1991; Sasaki and Kanazawa, 1998). For among-group comparisons, dental data from 16 ancient and contemporary groups with various ethnic ancestries were gathered from the

*TABLE 1. Sex distribution and sample size of the contemporary Colombian ethnic groups analyzed**

African Americans (Guapi)			African Americans (Villarica)			Guambiano Amerindians (Silvia)			Admixed/Mestizo (Popayán)		
M	F	T	M	F	T	M	F	T	M	F	T
32	36	68	10	9	19	30	26	56	29	28	57
47.1%	52.9%	100%	52.6%	47.4%	100%	53.6%	46.4%	100%	50.8%	49.2%	100%

*Codes are Males (M), Females, and Total (T)

TABLE 2. Dental samples used for population comparisons

	Code	Sample Name	Area Area	Cultural Affiliation	Period	Sample Size	Citation
1	Japan	Japanese	Japan	Asiatic	Contemporary	183	Hanihara, 1963, 1968, 1965
2	arc	Prehistoric Amerindian	Ohio Valley	Late Archaic	3200-2700 BP	64	Sciulli, 1990, 1998
3	wood	Prehistoric Amerindian	Ohio Valley	Woodland E-M-L	2700-1000 BP	34	Sciulli, 1990, 1998
4	pear	Prehistoric Amerindian	Ohio Valley	Late Prehistoric Pearson/Anderson	1000-350 BP	61	Sciulli, 1990, 1998
5	sunw	Prehistoric Amerindian	Ohio Valley	Late Prehistoric Sun Watch	1000-350 BP	76	Sciulli, 1990, 1998
6	mono	Prehistoric Amerindian	Ohio Valley	Monongahela	1000-350 BP	62	Sciulli 1990, 1998
7	buff	Prehistoric Amerindian	Ohio Valley	Late Prehistoric Buffalo	1000-350 BP	73	Sciulli, 1990, 1998
8	pima	Contemporary Amerindian	Arizona	Pima So. Arizona	Contemporary	100	Tocheri, 2002
9	safr	South Africans	South Africa	Natal Nguni Cape Nguni	Contemporary Prehistoric	53	Grine, 1986
10	wafr	West African	-	-	Contemporary	18	Lease 2003
11	afm.wash	African American	Washington USA	African	Contemporary American	249	Hanihara, 1963, 1965
12	afm.mem	African American	Memphis Tennessee	African American	Contemporary	117	Lease, 2003
13	afm.dall	African American	Dallas, Texas	African American	Contemporary	101	Lease, 2003
14	England	English	London	European	Contemporary	86	Lease, 2003
15	eua.usa	No. American White	Cleveland, Ohio	European	Cnotemporary Americans	100	Lease, 2003
16	India	Prehistoric India	West India	Inamgaon	Calcolithic 1600-700 BC	45	Lukacs, Walimbe, 1984

literature, and these are listed in Table 2. Information regarding analyzed dental traits, break points, and frequencies in Colombian groups are presented in Tables 3 and 4. Of the total traits analyzed, 18 were used for group comparisons in the multivariate analysis (Table 5).

Statistical Analyses

The first step in the statistical analysis was testing dental trait frequency differences between males and females. This procedure was done by means of the Pearson chi-square test to detect significance ($P < 0.05$). The next step was to obtain phenetic relatedness between samples using a multivariate analysis of principal components (PCA) using SPSS 14.0 software. Despite the numerous methods available for population comparisons using dichotomous data such as B-squared distance, correspondence analysis, pseudo-Mahalanobis' D^2, Euclidean distance, average taxonomic distances, among others, anthropologists have focused almost

TABLE 3. Maxillary deciduous trait frequencies in four contemporary Colombian populations

Trait	Dichotomies	Guapi n	Guapi k	Guapi %	Villarica n	Villarica k	Villarica %	Silvia n	Silvia k	Silvia %	Popayan n	Popayan k	Popayan %	Citation
Shovel ui1	2-3/0-3	20	2	10.0	2	0	0.0	17	16	94.1	11	4	36. 6	Hanihara, 1963
Shovel ui2	2-3/0-3	36	3	8.3	7	0	0.0	24	22	91.6	15	7	46.6	Hanihara, 1963
Shovel uc	2-3/0-3	60	5	8.3	18	0	0.0	50	39	78.0	46	15	32.2	Hanihara, 1963
Double shovel ui1	1-3/0-3	21	0	0.0	2	0	0.0	17	0	0.0	11	0	0.0	Sciulli, 1998
Double shovel ui2	1-3/0-3	36	0	0.0	7	0	0.0	24	0	0.0	14	1	7.1	Sciulli, 1998
Double shovel uc	1-3/0-3	60	3	5.0	18	2	11.1	51	1	2.0	41	4	8.5	Sciulli, 1998
Winging ui1	1-2/0-3	22	2	10.0	2	0	0.0	17	5	29.4	11	6	54.5	Dahlberg, 1963
Interruption grooves ui1	1-4/0-4	21	0	0.0	1	0	0.0	17	0	0.0	11	0	0.0	Sciulli ,1998, Turner *et al.*, 1991
Interruption grooves ui2	1-4/0-4	36	2	5.5	6	0	0.0	21	0	0.0	14	1	7.1	Sciulli, 1998, Turner *et al.*, 1991
Tuberculum dentale ui1	1-4/0-4	20	4	20.0	2	0	0.0	17	6	35.2	11	1	9.0	Grine, 1986
Tuberculum dentale ui2	1-4/0-4	35	6	17.1	6	0	0.0	22	9	41.0	14	3	21.4	Grine, 1986
Tuberculum dentale uc	1-4/0-4	60	48	80.0	18	11	61.1	53	42	79.2	47	29	61.7	Grine, 1986
Mesial ridge uc	ASU 1-3	59	8	13.5	18	0	0.0	52	11	21.1	47	6	12.7	Turner *et al.*, 1991
Distal accessory ridge uc	1-4/0-4	57	33	57.9	18	4	22.2	48	14	29.1	40	11	27.5	Sciulli, 1998, Turner *et al.*, 1991
Hypocone um1	4+4-/2-4	60	19	31.6	12	2	16.6	47	0	0.0	41	12	29.2	Hanihara, 1963
Hypocone um2	4+4-/3-4	68	67	98.5	18	18	100.0	55	55	100.0	50	49	98.0	Hanihara, 1963
Metacone um2	ASU 1-5	68	68	100.0	17	16	94.1	56	56	100.0	49	49	100.0	Turner *et al.*, 1991
Metaconule um2	ASU 1-5	67	13	19.4	18	5	27.7	56	3	5.3	47	5	10.6	Turner *et al.*, 1991
Carrabelli's um2	2-4/0-4	68	26	38.2	16	10	62.5	56	39	69.6	49	20	40.8	Grine, 1986

TABLE 4. Mandibular deciduous trait frequencies in four contemporary Colombian populations

		Guapi			Villarica			Silvia			Popayan			
Trait	Dichotomies	n	k	%	n	k	%	n	k	%	N	k	%	Citation
Double teeth li1	1	12	0	0.0	2	0	0.0	4	0	0.0	3	0	0.0	Sciulli, 1998
Shovel li1	2-3/0-3	10	0	0.0	2	0	0.0	8	8	100.0	4	0	0.0	Hanihara, 1963
Shovel li2	2-3/0-3	11	0	0.0	3	0	0.0	12	11	91.6	12	7	58.3	Hanihara, 1963
Tuberculum dentale lc	1-4/0-4	52	22	42.3	15	0	0.0	45	1	2.2	44	4	9.0	Grine, 1986
Distal accessory ridge lc	1-4/0-4	51	31	60.7	13	3	23.0	42	13	31.0	39	9	23.0	Sciulli, 1998, Turner *et al*., 1991
Cusp number lm2	5-8/2-8	65	65	100.0	16	16	100.0	50	50	100.0	43	43	100.0	Sciulli, 1998
Groove pattern lm2	Y/+-X-Y	65	63	97.0	15	15	100.0	50	50	100.0	42	41	97.6	Sciulli, 1998
Deflecting wrinkle lm2	1	65	34	52.3	15	7	46.6	46	35	76.0	42	19	45.2	Sciulli, 1998
Protostylid lm2	1-2/0-2	65	17	26.1	17	3	17.6	53	28	52.8	43	25	58.1	Grine, 1986
Mesiobucal groove lm2	1-3/0-3	66	66	100.0	17	16	94.0	52	52	100.0	43	41	95.0	Grine, 1986
Distal trigonid crest lm1	1-2/0-2	59	2	3.3	14	1	7.1	39	1	2.5	40	1	2.5	Sasaki, Kanazawa, 1998
Distal trigonid crest lm2	ASU 1-5	66	21	34.4	16	4	25.0	48	17	35.4	42	6	14.2	Turner *et al*., 1991
Medial trigonid crest lm1	1-2/0-2	60	57	95.0	14	13	93.0	38	32	84.2	40	38	95.0	Sasaki, Kanazawa, 1998
Medial trigonid crest lm2	1-2/0-2	65	13	20.0	15	2	13.3	48	4	8.3	42	2	4.7	Sasaki, Kanazawa, 1998
Delta form lm1	1	58	0	0.0	12	0	0.0	41	0	0.0	39	0	0.0	Sciulli, 1998
Cusp 5 lm2	ASU 1-5	65	64	98.4	15	15	100.0	50	50	100.0	43	43	100.0	Turner *et al*., 1991
Cups 6 lm2	1-4/0-4	65	8	12.3	15	3	20.0	50	30	60.0	40	13	32.5	Towsend *et al*., 1990
Cusp 7 lm2	1-3/0-3	65	28	43.0	15	6	40.0	49	4	8.1	41	11	26.8	Hanihara and Minamidate, 1965

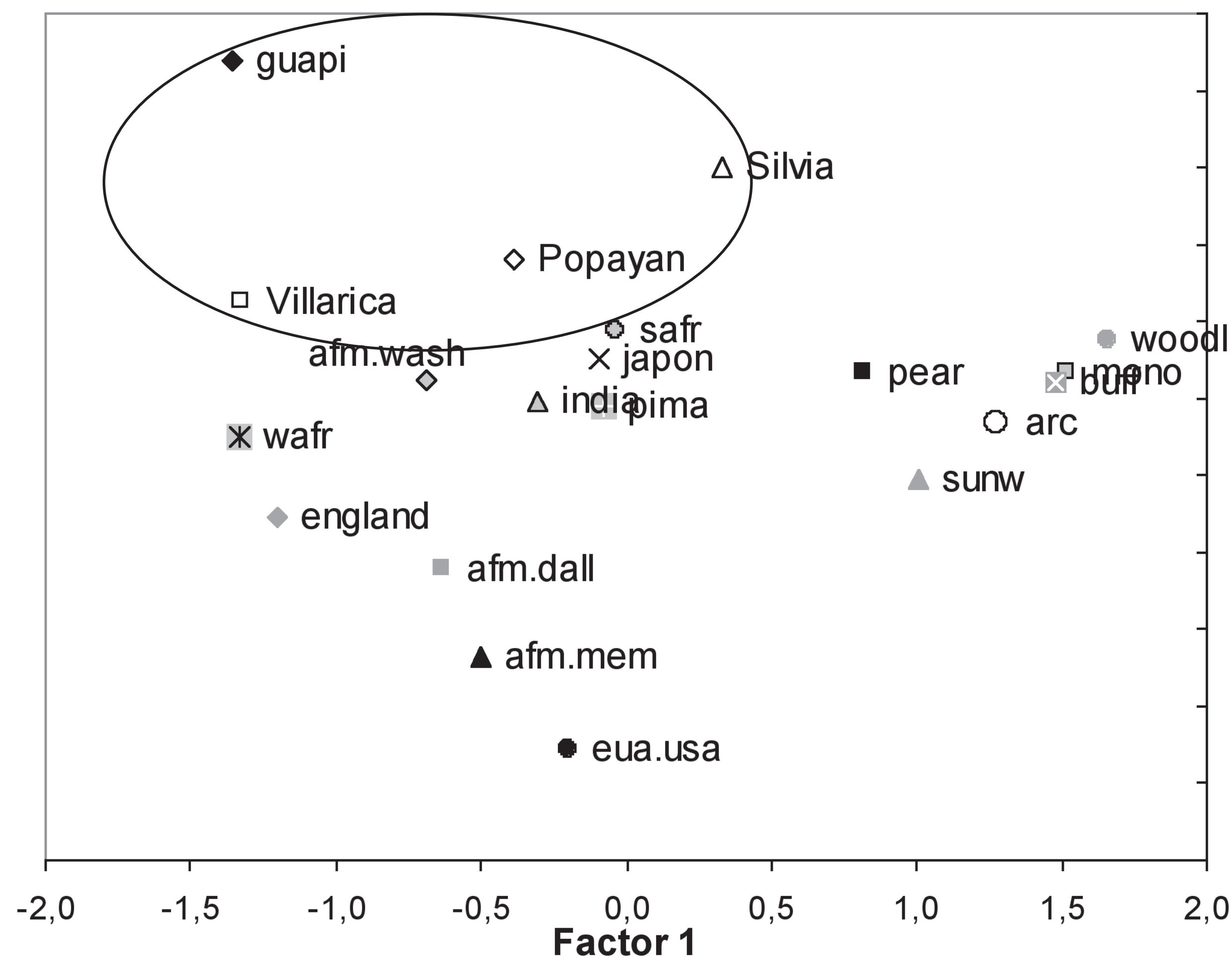

Fig. 2. Scatterplot of the first two components based on frequencies of traits in the deciduous dentition. A total of 20 samples are plotted. Axis 1 and 2 account for 50% of total variance (28.1% along X-axis and 21.5% along Y-axis). For codes and references see Tables 1 and 2. The ellipse includes the four Colombian samples studied.

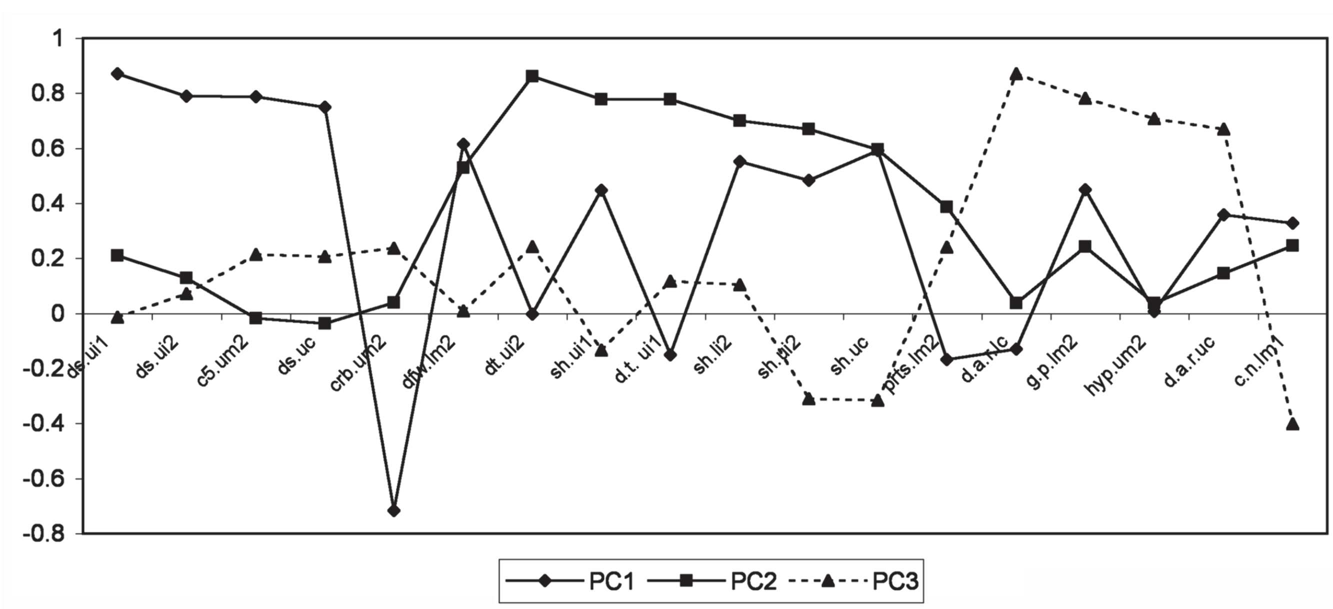

Fig. 3. Correlation coefficients (loadings) distribution in the three first principal components for 18 dental nonmetric traits between 20 populations of different ancestry with deciduous dentition. Accounts for 66.1% of total variance (28.1% PC1, 21.5% PC2, and 16.5% PC3).

exclusively on the use of C. A. B. Smith's mean measure of divergence (MMD) based on the distance concept or the degree of dissimilarity between samples (*e.g.*, Irish, 1993; Scott and Turner, 1997).

The power of other analytic methods in the assessment of population affinities such as PCA has not been totally explored. The variables submitted to PCA (trait frequencies) are parametric (ratio scale), and frequencies of nonmetric traits can be used to produce numerically derived population relationships.

Recent studies employed PCA to assess population affinities using discontinuous dental traits with good results (Cucina *et al.*, 2003; Coppa *et al.*, 2001; Irish and Guatelli-Steinberg, 2003; Stringer, 2002; Delgado-Burbano, 2007). In fact, Irish and Guatelli-Steinberg (2003) and Coppa *et al.* (2007) compare PCA in great detail with other methods; in their case with statistics of distance as MMD, and they found very similar results, suggesting the reliability of PCA in the study of human population affinities using nonmetric traits.

The main benefit of PCA is that the reduced, conceptually more coherent, set of components is often easier to comprehend than the larger collection of potentially correlated variables (Irish and Guatelli-Steinberg, 2003). However, the key reason for using PCA in the present study is that the correlations computed between original variables and components identify those dental traits that are most responsible for inter-sample variation. Only components with an eigenvalue higher than 1.0 were taken into account. Those correlation coefficients between a variable and the component that were higher than 0.6 were considered pertinent (Alfredo Coppa, personal communication, 2007).

The inter-group relationships based on the first two components—which contain much of the total variance—were plotted to discern relationships among samples via scatterplots produced by the graph function of SPSS 14.0.

RESULTS

The Colombian ethnic groups analyzed here did not exhibit significant sexual dimorphism in deciduous nonmetric traits. Two exceptions are for the Mestizo sample that exhibited two dental traits with significant male-female differences, namely Bushman canine uc ($P = 0.037$; 2 df) and Carabelli Tubercle um1 ($P = 0.028$; 2 df). Irish (1993) suggested that dental traits exhibiting significant sexual dimorphism of less than 10% do not affect the population relationships. These traits only represent 5.4% (*i.e.*, 2 of 37) and, accordingly, were not removed from the analysis. Subsequently, sexes were combined for the study of intergroup affinities.

Intergroup relationships are presented in Fig. 2. The PCA data for dental variants are presented in Table 5, which show the component loadings, eigenvalues, and percentages of variance explained by the dental traits. Fig. 3 depicts the significant correlation coefficients from among the 18 dental traits based on the PCA. PCA yielded three components that collectively account for 66.1% of the total variance. In each component, 16 dental traits were identified with significant positive (> 0.6) and negative (> -0.6) correlation coefficients (loadings). In the first component (28% of total variance) six dental traits were identified, five with positive and one with negative loadings (Table 5). High frequency dental traits with a positive correlation coefficient characterize all populations with Asian-Sinodont ancestry. In fact, North and South Native American samples (both prehistoric and contemporary) and recent Asians (Japan) have high frequencies of these traits, which are ubiquitous in the "Mongoloid dental complex" (Hanihara, 1966). Some other groups with non-Asiatic ancestry also have high frequencies (African-Colombian, South Africans and Mestizo). On the other hand, one trait with a negative significant correlation coefficient in the first component was also identified. This has middle to high frequencies in Africans, African-Americans from North and South America, European-Americans and South Asians (India) analyzed here. Interestingly, all four Colombian samples have high frequencies of these traits. Their high frequency in African-Colombians and Mestizo groups is not surprising. However, Colombian Amerindians (Guambianos) have the second highest frequency after South Africans (based on the study by Grine, 1986). This observation possibly reflects high rates of admixture with populations of African or European ancestry.

In the second canonical axis (21.5% of total variance) six deciduous dental traits with positive significant correlation coefficients were identified. Once again, these traits characterize Asian-derived populations. Shovel ui1 is in high frequency in recent Japanese, prehistoric Native North Americans and contemporary Colombian Amerindians. Recent North-American Indians (Pima) have intermediate frequencies. African-Americans from Dallas and Memphis (Lease, 2003) have high frequencies, suggesting admixture with Amerindians. This same pattern of biogeographic distribution is recognized for shovel shape in ui2, uc and li1. Europeans, European Americans and Mestizo samples share middle to high frequencies. Tuberculum dentale ui1 has high frequencies in African-Colombians from Guapi, European-Americans and Colombian Amerindians. Tuberculum dentale ui2 has similar frequencies in human groups with different ancestry; however, it showed a slight increase in Native Americans in general and in Colombian Mestizos.

Finally, the third canonical axis (16.5% of total variance) identified four dental traits with significant positive loadings, however their population distributions are totally disparate. The first two dental traits (distal accessory ridge in upper and lower canines) have high frequencies in African-Colombians, West Africans, prehistoric North American Indians and recent Colombian Amerindians and Mestizo. Other

TABLE 5. Component loadings, eigenvalues and variances for dental nonmetric traits in 20 populations of different ancestry with deciduous dentition[1]

	Contribution of the Components		
Trait	PC1	PC2	PC3
Double shovel ui1	**0.87**	0.21	-0.01
Double shovel ui2	**0.79**	0.13	0.07
Cusp 5 um2	**0.79**	-0.02	0.21
Double shovel uc	**0.75**	-0.04	0.21
Carabelli um2	**-0.72**	0.04	0.24
Deflecting wrinkled lm2	**0.62**	0.53	0.01
Dental tubercle ui2	0.00	**0.86**	0.24
Shovel ui1	0.45	**0.78**	-0.13
Dental tubercle ui1	-0.15	**0.78**	0.12
Shovel li2	0.55	**0.70**	0.10
Shovel ui2	0.48	**0.67**	-0.31
Shovel uc	0.59	**0.60**	-0.32
Protostylid lm2	-0.17	0.39	0.24
Distal accesrory ridge lc	-0.13	0.04	**0.87**
Groove Pattern lm2	0.45	0.24	**0.78**
Hypocone um2	0.01	0.04	**0.71**
Distal accesory ridge uc	0.36	0.14	**0.67**
Cusp number lm1	0.33	0.25	-0.40
Eigenvalue	5.05	3.88	2.98
Variance (%)	28.06	21.56	16.57
Cumulative Variance	28.06	49.62	66.19

[1]Highlighted entries denote relatively high positive and negative loadings within that particular component.

human groups studied here have low or medium-low frequencies. The next two dental traits identified (hypocone um2 and groove pattern lm2) have very similar frequencies among human groups with different ethnic and biological ancestry. Hypocone um2 occurs in very high frequencies in all samples, ranging from 77% to 100%. An exception is presented for European-Americans (Lease, 2003) who have very low frequency (36%). This finding is possibly related to selection pressures—or simply sampling fluctuation. It is notable that this finding also occurs in New World African derived groups from Colombia (Delgado-Burbano, 2006). Groove pattern lm2 has nearly identical (90-100%) frequencies across all dental samples, except European and African descendents from North America who have very low frequencies, which suggests intensive gene flow from ethnic groups of different ancestry.

Fig. 4 shows a comparison of the frequencies of those 16 dental traits most responsible for inter-group variation in the PC analysis (Table 5) among four Colombian samples analyzed. The fluctuations of dental trait frequencies reflect well the ancestry and microevolutionary dynamics between Colombian groups. Table 5 shows that dental traits with significant positive correlation coefficients in PC scores 1 and 2 characterize Native Americans and recent Asian populations (Sinodonts) (but see loading of Carabelli tubercle on PC1). Conversely, PC score 3 distinguishes groups with African and European ancestry. However, this pattern is very dynamic since some Asian-descendent samples have high frequencies of African and European dental traits and vice versa. In fact, Fig. 2 and 4 demonstrate that all Colombian groups have a relatively close biological relatedness to one another, as well as display a mixture of Asian and European-African dental morphological characters.

Within the four Colombian samples, Tables 3-5 and Fig. 4 show that African-Colombians have high frequencies of distal accessory ridge uc, hypocone um2, Carabelli tubercle um2 and groove pattern lm2. On the other hand, Guambiano Amerindians have very high frequencies of shoveling and double shoveling in upper and lower central and lateral incisors and canines. Nonetheless this group has similar frequencies of the same dental traits that characterize African-Colombians (Fig. 4). Mestizos have traits very similar to African-Americans and to Amerindians, confirming their highly admixed gene pool.

DISCUSSION

Ethnic groups of disparate ancestry are unevenly distributed around Colombia, and their patterns of

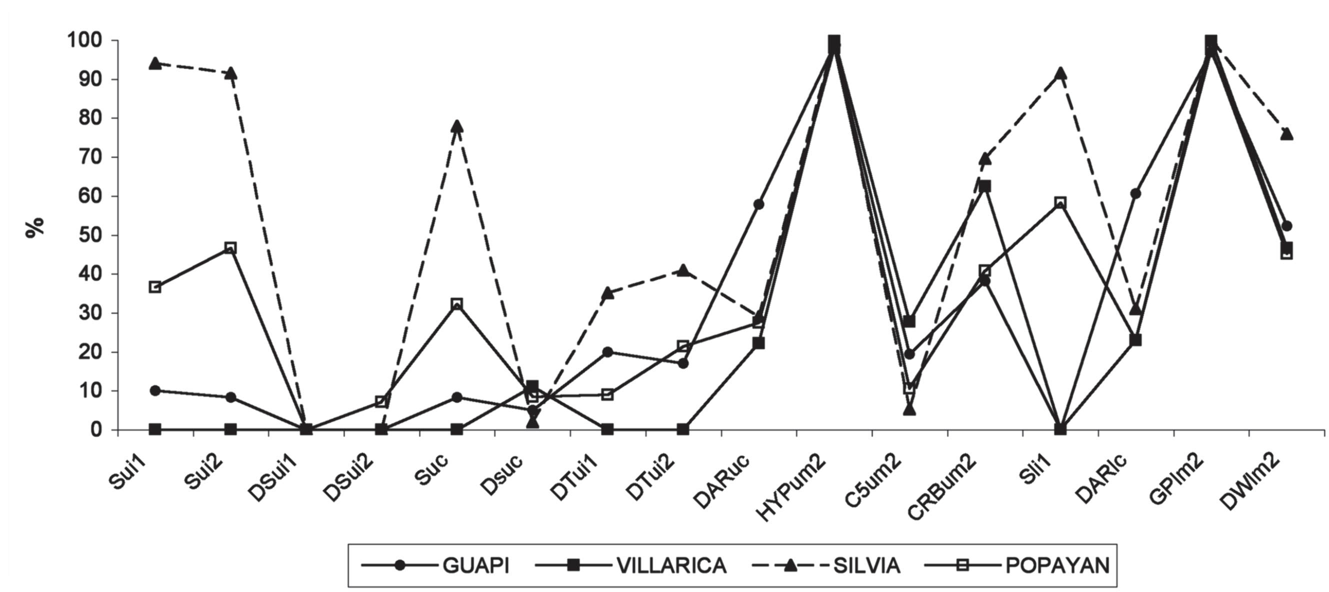

Fig. 4. Comparisons of the frequencies of 16 deciduous dental nonmetric traits more important for inter-sample variation according to PCA between four Colombian samples.

admixture vary considerably between and within regions. Some areas, such as Northwestern Colombia, were settled predominately by European males who admixed with Native American females. Other regions, such as the Pacific basin, have appreciable African ancestry. On the other hand, the Andean area is predominately Amerindian. Typically, neo-American societies were founded by populations with a high and medium maternal Amerindian contribution and a substantial European paternal contribution. In some American regions, in addition, variable percentages of paternal and/or maternal African contributions are also evident (Delgado-Burbano, 2007). For instance, one can find "Amerindian continental regions" (Peru, Mexico, Bolivia, Chile), "African continental regions" (Brazil and some areas of Colombia, Venezuela and Ecuador) and "European continental regions" (Argentina, Uruguay, Northwestern Colombia).

The evolutionary dynamics of contemporary Colombian populations have been analyzed almost exclusively by means of genetic markers (Ruiz-Linares *et al.*, 1999; Mesa *et al.*, 2000; Keyeux *et al.*, 2002; Rodas *et al.*, 2003; Carvajal-Carmora *et al.*, 2000; Bedoya *et al.*, 2006; Briceño *et al.*, 2003; Melton *et al.*, 2007; Bortolini *et al.*, 2004; Salas *et al.*, 2004, 2005). In consequence, little is known about the variation of morphological dental traits in these populations.

The population affinity analysis carried out here (Fig. 2) shows that Guambiano Amerindians have some affinities with prehistoric Native North Americans, but "close" affiliations with contemporary North American Indians and recent Northeast Asians were not evident. Recent molecular studies show close affinities between Guambiano and other Native American populations from the Amazonas and Orinoco basin (Keyeux and Usaquen, 2005)—in contrast to a lack of affinity with North and Central American indigenous groups.

Interestingly, the present analysis also presents a more distant affinity with recent North American Amerindians, which agrees with the above-mentioned mtDNA analysis (Keyeux *et al.*, 2002). Guambiano has predominately Sinodont dental traits; however, its high frequency of Carabelli tubercle possibly reflects European and/or African admixture. Previous genetic analysis based on blood groups corroborate this finding, suggesting that Guambiano-speaking people have 4.9% percent of African-descendent haplotypes as well as an unknown proportion of European admixture (Yunis *et al.*, 2001). This indigenous group is characterized by conservative mating customs and deep cultural roots (Camacho, 1996). However, this dental study and genetic analyses show that their recent history underwent rather intensive gene flow from groups of different ancestry, specifically from Mestizos and/or African-descendents.

The sample of Colombian hybrids (Mestizos from Popayán) analyzed here has a high Amerindian and African component, while a European component is less evident. The history of Popayán dates back to the 16th century when Spanish conquerors founded this city. European male and Criollo (Spaniards born in American colonies) contributed substantially to the emergent population. Traditional Popayán inhabitants are culturally and phenotypically identified with their European ancestors. However, contrary to other Colombian regions such as Antioquia or Bogotá, Amerindian and African contributions are high. This trend reflects the general situation where high rates of gene flow among very different ethnic groups occur in urban centers in many Latin America countries (Sans, 2000). Rodas *et al*. (2003); Carvajal-Carmora *et al*. (2000) and Bedoya *et al*. (2006) previously showed that other Colombian Mestizo populations also have a high Amerindian component, but without a corresponding European or African contribution. The proportions of admixture for Northwestern Colombian region of Antioquia are as follows: 94% European, 5% African and 1% Amerindian (Y-Chromosome data) and 2% European, 8% African and 90% Amerindian (mtDNA data) (Carvajal-Carmora *et al.*, 2000; Bedoya *et al.*, 2006). Mestizos from Bogotá have 78% percent of Amerindian lineages (A = 37.4 and B = 26.4%) and 22% of European lineages (16.5% of H, T, U V, W and 2.2% of J or K or African haplotypes) (Rodas *et al.*, 2003). The present dental analysis disagrees with these genetic studies since it suggests high African admixture and very low levels of gene flow from Europeans. This finding is interesting because Popayán inhabitants have a predominantly "European" cultural identity. However, this situation may be different in other Colombian regions.

Little is known about the microevolution and diversification of Africans and their descendents in Colombia. Only in the last decade have African-Colombians been studied from a genetic point of view (Rodas *et al.*, 2003; Keyeux, 1993; Keyeux *et al.*, 2000; Bortolini *et al.*, 2004; Salas *et al.*, 2004, 2005). Traditionally, historical and anthropological studies have shown clear cultural, linguistic, and religious similarities among Afro-Colombians and western African Bantu-speakers (Schwengler, 1992; Colmenares, 1997; Del Castillo, 1982). Previous dental studies show that African-Colombians have close biological affinities with Sub-Saharan Africans (Delgado-Burbano, 2006, 2007). Specifically, samples from Western and Central Africa such Gabon, Congo Pygmy, Nigeria, Cameroon, Togo and Benin display dental morphological similarities with Afro-Colombians. This dental relatedness has been confirmed by mtDNA studies as well as historical records (Rodas *et al.*, 2003; Keyeux *et al.*, 2000; Salas *et al.*, 2004, 2005; Bortolini *et al.*, 2004; Del Castillo, 1982).

Additionally, these dental studies show unexpected population relationships between African-Colombians and eastern (Kenya and Tanzania) and southeastern Africans (South-Africa). In fact, these regions played a very important role in the importation of African slaves to Colombia—more than previously assumed. As Salas *et al*. (2005:857) pointed out: "there is also some indication of a Mozambican component in African-Americans of the Colombian Pacific Coast [*i.e.* Chocó] represented by the characteristic South eastern African mtDNA haplogroup founder L0a2 and moreover the L3e1* type present is typically Southeast African."

Interestingly, the landscape of genetic relatedness of African-Colombians and other South-African-Americans are almost identical to the affinities displayed by dental nonmetric data. Dental information of African-Colombian samples analyzed here is consistent with previous dental analysis (Delgado-Burbano, 2006, 2007). Guapi and Villarica populations show close relationships with Western Africa. Although a close relationship with South Africa is not evident, the pattern of phenotypic affinities of African-Colombians suggests that Sub-Saharan Africa, specially western, eastern and southeastern Africa are important origin regions.

Fig. 2 shows that African-American Colombian samples have clear affinities with African-Americans from Washington but not with African-Americans from Memphis and Dallas (comparative data from Lease, 2003). This finding could suggest both different ethnic origins of African-American populations in the Americas and/or distinct microevolutionary histories. Previous dental analyses (Lease, 2003; Delgado-Burbano, 2007) show that North-African-Americans have close affinities with European-Americans due to intensive gene flow that modified their gene pools and therefore their biological associations with other African-descendent populations and their African ancestors. Rodas *et al*. (2003) based mtDNA haplogroup analysis shows asymmetrical patterns of admixture in African-Colombians that disagree with the present study. Several samples from the Pacific basin have medium and high admixture with Native Americans. Specifically a significant proportion of Amerindian lineages A (mean frequency: 8.2%) and B (mean frequency: 10.6%) were detected. Although frequencies of incisor shoveling and deflecting wrinkle in Guapi and Villarica possibly indicate the presence of a Native American component in their gene pool, population affinities shown in Fig. 2 and dental frequencies presented in Fig. 4 imply a low rate of admixture between Colombian Native Americans and African-descendents, in agreement with more recent mtDNA analysis (Salas *et al.*, 2004, 2005).

In conclusion, Colombian samples analyzed here present a complex history, where gene flow probably was the main factor configuring the contemporary gene pools. Although some samples show disparate ancestries in their dental morphology (*i.e.*, Mestizo), other groups (African-Colombians and Amerindians) appear to share close relationships with their sister and parental populations. Patterns of phenotypic diversity of these Colombian groups probably parallel those that have occurred in other Latin-American populations in similar historical contexts.

ACKNOWLEDGMENTS

I thank the Colombian communities that participated in this study; without their help it would not have been possible. This study was partially supported by a grant of the Colombian Institute for the Development of

Science and Technology COLCIENCIAS (1103-04-11985) and Antropos and Antropacifico research groups of the Department of Anthropology, University of Cauca, Colombia. Thanks to Alexandra Delgado for grammatical editing of the manuscript. Thanks to Dr. Javier Rosique (Department of Anthropology, Antioquia University, Colombia) for his useful comments and assistance.

LITERATURE CITED

Bedoya G, Montoya P, García J, Soto I, Burgeois S, Carvajal L, Labuda D, Alvarez V, Ospina J, Hedrick PW, Ruiz-Linarez A. 2006. Admixture dynamics in Hispanics: a shift in the nuclear genetic ancestry of a South American population isolate. Proc Natl Acad Sc USA 103:7234-7239.

Bortolini MC, Silva-Jr WA, Zago MA, Elion J, Krishnamoorth R, Gonçalves VP, Pena SD. 2004. The phylogeography of mitochondrial DNA haplogroup L3g in Africa and the Atlantic slave trade. Am J Hum Genet 74:523-524.

Briceño I, Gomez, A, Lozano PA. 2003. Mitochondrial variation in Colombia: study of matrilineal lineages among Amerindian tribes. XIX Proceedings of the International Congress of Genetics, Melbourne.

Carvajal-Carmora LG, Soto ID, Pineda N, Ortiz-Barrientos D, Duque C, Ospina-Duque J, McCarthy M, Montoya P, Álvarez VM, Bedoya G, Ruiz-Linares A .2000. Strong Amerind/white sex bias and possible Sephardic contribution among the founders of a population in the Northwestern Colombia. Am J Hum Genet 67:1287-1295.

Colmenares G. 1997. Historia Económica y Social de Colombia II. Popayán una Sociedad Esclavista. 1680-1800. Bogotá. La Carreta Inéditos Ltda.

Coppa A, Cucina A, Lucci M, Vargiug R, Maccinelli D. 2007. Origins and spread of agriculture in Italy: a nonmetric dental analysis. Am J Phys Anthropol 133:918-930.

Coppa A, Di Cinto F, Vargiu R, Maccinelli D, Lucci M. 2001. Morphological dental traits to reconstruct phenetic relationships between Late Pleistocene-Ancient Holocene human groups from Eurasia and North Africa. Am J Phys Anthropol (Suppl) 32:54

Cucina A, Luna F, Vargiu R, Coppa A. 2003. Las poblaciones caribeñas desde el tercer milenio AC a la conquista española: las filiaciones biológicas desde la perspectiva antropológica dental. Estudios de Antropología Biológica XI:913-927.

Del Castillo NM. 1982. Esclavos Negros en Cartagena y sus Aportes Léxicos. Bogotá. Instituto Caro y Cuervo.

Delgado-Burbano ME. 2006. Historia poblacional, orígenes Africanos y microevolución de los actuales Afro-Colombianos inferidos desde caracteres epigenéticos en la dentición decidua y permanente. Rev Arg Antropol Biol 8:85-109.

Delgado-Burbano ME. 2007. Population affinities of African Colombians to Sub-Saharan Africans based on dental morphology. Homo 58:329-356.

Edgar H, Lease L. 2007. Correlations between deciduous and permanent mandibular molars in a European-American sample. Am J Phys Anthropol 133:726-734.

Ethnologue 2001. Language of the World. 14th ed. Electronic version. Http://ethnologue.com/snow_country.asp?name=Colombia.

Grine FE. 1984. The deciduous dentition of the Kalahari San, the South African Negro and the South African Plio-Pleistocene hominids. Ph.D. dissertation. Johannesburg. University of Witwatersrand. South Africa.

Grine FE. 1986. Anthropological aspects of the deciduous teeth of South African blacks. In: Singer RJ, Lundy, editors. Variation, culture and evolution in African populations. Johannesburg. Witwatersrand University Press, p 47-83.

Grine FE. 1990. Deciduous dental features of Kalahari San: comparisons of non-metrical traits. In: Sperber GH, editor. From the apes to angels. New York. Wiley-Liss, p 153-169.

Hanihara K. 1956a. Studies on the deciduous dentition of the Japanese and the Japanese-American hybrids. III. Deciduous lower molars. J Anth Soc Nippon 65:95-115.

Hanihara K. 1956b. Studies on the deciduous dentition of the Japanese and the Japanese-American hybrids. IV. Deciduous upper molars. J Anth Soc Nippon 65:67-87.

Hanihara K. 1961. Criteria for the classification of crown characteristics of the human deciduous dentition. J Anth Soc Nippon 69:27-45.

Hanihara K. 1963. Crown characters of the dentition of the Japanese-American hybrids. In: Brothwell DR, editor. Dental anthropology. London: Pergamon Press, p 104-124.

Hanihara K. 1965. Some crown characters of the deciduous incisors and canines in Japanese-American hybrids. J Anth Soc Nippon 72:135-145.

Hanihara K. 1966. Mongoloid dental complex in the deciduous dentition. J Anth Soc Nippon 74:61-71.

Hanihara K, Minamidate T. 1965. *Tuberculum accesorium mediale internum* in the human deciduous lower second molars. J Anth Soc Nippon 73:9-18.

Irish JD. 1993. Biological affinities of Late Pleistocene through modern African aboriginal populations: the dental evidence. Ph.D. Dissertation, Arizona State University, Tempe Arizona.

Irish J, Guatelli-Steinberg D. 2003. Ancient teeth and modern human origins: an expanded comparison of African Plio-Pleistocene and recent world dental samples. J Hum Evol 45:113-144.

Jaramillo-Correa JP, Keyeux G, Ruiz-Garcia M, Rodas C, Bernal. 2001. Population study of the genes

APOE, APOB(3'VNTR) and ACE in some Black and Amerindian communities from Colombia. Hum Hered 52:14–33.

Jørgensen K. 1956. The deciduous dentition: a descriptive and comparative anatomical study. Acta Odont Scand 14:1-202.

Keyeux G, Usaquén W. 2005. Rutas migratorias hacia Sur América y el poblamiento de las cuencas de los ríos Amazonas y Orinoco deducidas a partir de estudios genéticos moleculares. In Pueblos y Paisajes Antiguos en la Selva Tropical Amazónica, p 1-30.

Keyeux G, Rodas C, Gálvez N, Carter D. 2002. Possible migration routes into South America deduced from mtDNA studies in Colombian Amerindian populations. Hum Biol 74:211–233.

Keyeux G, Rodas C, Bernal JE. 2000. Haplotipos fundadores del DNA mitocondrial en poblaciones colombianas: aporte a los estudios en América. In: Bernal J, editor. Geografía Humana de Colombia. Instituto Colombiano de Cultura Hispánica, p 453-466.

Kitagawa Y. 2000. Nonmetric morphological characters of deciduous teeth in Japan: diachronic evidence of past 4000 years. Int J Osteoarch 10:242-253.

Lease L. 2003. Ancestral determination of African-Americans and European-Americans deciduous dentition using metric and non-metric analysis. Ph.D. dissertation. Ohio State University, Columbus, Ohio.

Lease L, Sciulli P. 2005. Brief communication: discrimination between European-American and African-American children based on deciduous metrics and morphology. Am J Phys Anthropol 126:56-60.

Lukacs J, Hemphill B. 1991. The dental anthropology of prehistoric Baluchistan: a morphometric approach to the peopling of South Asia. In: Kelley M, Larsen CS, editors. Advances in dental anthropology. New York: Willey-Liss, p 77-119.

Lukacs, JR, Walimbe SR. 1984. Deciduous dental morphology and the biological affinities of a Chalcolithic skeletal series from Western India. Am J Phys Anthropol 65:23-30.

Melton PE, Briceño I, Gomez A, Crawford M, Benal J. 2007. Biological relationships between Central and South American Chibcha speaking populations: evidence from mtDNA. Am J Phys Anthropol 133:753-770.

Mesa N, Mondragón M, Soto I, Parra MV, Duque C, Ortíz-Barrientos D, García LF, Vélez ID, Bravo ML, Múnera GJ, Bedoya G, Bortolini MC, Ruiz-Linares A. 2000. Autosomal mtDNA, and Y-chromosome diversity in Amerinds: pre- and post-Columbian patterns of gene flow in South America. Am J Hum Genet 67:1277-1286.

Moskona D, Vainder M, Hershkovitz I, Kobyliansky E. 1998. Dentition peculiarities in human isolates—South Sinai Beduin tribes. In: Mayhall J, Heikkinen T, editors. Dental morphology 1998: 11th International symposium on dental morphology. Oulu: Finland, p 74-84.

Nichol C. 1989. Complex segregation analysis of dental morphological variants. Am J Phys Anthropol 78:37-59.

Pachón X. 1996. Los Wampi o la gente de Guambía. In Pachón X, Oliveros E, Wiesner L, editors. Geografía Humana de Colombia. Región Andina. Instituto Colombiano de Cultura Hispánica. Colombia, p 11-85.

Rocha L, Rivas H, Moreno F. 2007. Frecuencia y variabilidad de la morfología dental en niños Afro-Colombianos de una institución educativa en Puerto Tejada, Cauca, Colombia. Colombia Médica 38:210-221.

Rodas C, Gelvez N, Keyeux G. 2003. Mitochondrial DNA studies show asymmetrical Amerindian admixture in Afro-Colombian and Mestizo populations. Hum Biol 75:13-30.

Ruiz-Linares A, Ortíz-Barrientos D, Figueroa M, Mesa N, Múneras JG, Bedoya G, Vélez ID, García FL, Pérez-Lezaun A, Bertranpetit J, Feldman MV, Goldstein DV. 1999. Microsatellites provide evidence for Y chromosome diversity among the founders of the New World. Proc Natl Acad Sci USA 96:6312-6317.

Salas A, Richards M, Lareu MV, Scozzari R, Coppa A, Torroni A, Macaulay V, Carracedo A. 2004. The African diaspora: mitochondrial DNA and the Atlantic slave trade. Am J Hum Genet 74:454-465.

Salas A, Richards M, Lareu MV, Sobrino B, Silva S, Matamoros M, Macaulay V, Carracedo A. 2005. Shipwrecks and founder effects: divergent demographic histories reflected in Caribbean mtDNA. Am J Phys Anthropol 128:855-860.

Schwengler A. 1992. Hacia una arqueología afrocolombiana: Restos de tradiciones religiosas Bantúes en una comunidad negro-colombiana. América Negra 4:35-82.

Sans M. 2000. Admixture studies in Latin America: from 20th to 21st century. Hum Biol 72:155-177.

Sasaki K, Kanazawa E. 1998. Morphological traits on dentino-enamel juction of lower deciduous molar series. In: Mayhall J, Heikkinen T, editors. Dental morphology 1998: 11th international symposium on dental morphology. Oulu, Finland: University of Oulu, p 167-178.

Sciulli PW. 1977. A descriptive and comparative study of deciduous dentition of prehistoric Ohio Valley Amerindians. Am J Phys Anthropol 47:71-80.

Sciulli, PW. 1990. Deciduous dentition of a Late Archaic population of Ohio. Hum Biol 62:221-245.

Sciulli PW. 1998. Evolution of the dentition prehistoric Ohio Valley Native Americans: II. morphology of the

deciduous dentition. Am J Phys Anthropol 106:189-205.
Scott GR. 1980. Population variation of Carabelli´s trait. Hum Biol 52:63-78.
Scott RG, Turner CG II. 1997. The anthropology of modern human teeth: dental morphology and its variation in recent human populations. Cambridge: Cambridge University Press.
Smith P. 1978. Evolutionary changes in the deciduous dentition of Near Eastern populations. J Hum Evol 7:401-408.
Smith PE, Koyoumdisky-Kaye, Kalderon W, Stern D. 1987. Directionality of dental trait frequency between human second deciduous and first permanent molars. Arch Oral Biol 32:5-9.
Tocheri M. 2002. The effect of sexual dimorphism, asymmetry and inter-trait association on the distribution of thirteen deciduous dental nonmetric traits in a sample of Pima Indians. Dental Anthropology 15:1-9.
Townsend GC, Martin N. 1992. Fitting genetic models to Carabelli trait data in South Australian twins. J Dent Res 71:403-409.
Townsend GC, Brown T. 1981. The Carabelli trait in Australian aboriginal dentition. Arch Oral Biol 26:809-814.
Townsend GC, Yamada H, Smith P. 1986. The metaconule in Australian aboriginals: an accessory tubercle on maxillary molar teeth. Hum Biol 58:851-862.
Townsend GC, Yamada H, Smith P. 1990. Expression of the entoconulid (sixth cusp) on mandibular molar teeth of an Australian aboriginal population. Am J Phys Anthropol 82:267-274.
Turner CG, Nichol C, Scott R. 1991 Scoring procedures for key morphological traits of the permanent dentition: the Arizona State University Dental Anthropology System. In: Kelley M, Larsen CS, editors. Advances in dental anthropology. New York: Willey-Liss, p 13-31.
Ullinger, J. 2003. A comparison of morphological traits in deciduous and permanent dentition. Am J Phys Anthropol (Supp) 36:212.
Yunis JJ, Yunis EJ, Yunis E. 2001. Genetic relationship of the Guambino, Paez, and Ingano Amerindians of Southwest Colombia using major histocompatibility complex class II haplotypes and blood groups. Hum Immunol 62:970-978.

Morphology of Root and C-Shape Canal in Prehispanic and Modern Maya Groups from Northern Yucatan

Andrea Cucina,[1] Elma Vega Lizama,[2] Marco Ramírez,[2] G. Alvarado Cárdenas,[2] and Vera Tiesler[1]

[1]*Facultad de Ciencias Antropológicas, Universidad Autónoma de Yucatán, Mérida, Yucatán, México;* [2]*Facultad de Odontología, Universidad Autónoma de Yucatán, Mérida, Yucatán, México*

ABSTRACT One-rooted mandibular second molars are labelled "C-molar" because of the root's morphology. The frequency of C-molars is strongly associated with ethnic origin, being most common in North-East Asians. The present study analyzed the frequency of one-rooted molars and associated pulpal chamber in 48 Prehispanic Mayans and in 142 modern subjects studied at the School of Endodontics, UADY. The frequency of one-rooted molars in the Prehispanic sample is 35%, with 32% of these having C-canals. Similarly, 42 of 142 (30%) modern teeth exhibit a C-canal. The similarity between ancient and modern samples suggests that genetic admixture since the European conquest has not affected trait expression, and it implies that the Maya express the Sinodontic pattern of dental morphology. Endodontically, the significant correlation between C-molar and C-canal is an advantage for recognizing the canal's anatomy if treatment is indicated. *Dental Anthropology* 2008;21(2):46-49.

The dental morphology of Maya populations belongs to the Sinodont family (Turner, 1990) and falls into the Sino-American group (Scott and Turner, 1997). It is characterized by, among other features, a high frequency of undivided roots in the lower second molar (Scott and Turner, 1997). Root morphology is one of the many traits commonly employed in dental studies of population affinities. Mandibular second molars are described according to a one- or two-roots dichotomy (with the very rare cases of three roots falling into the two-roots category) (Turner *et al.*, 1991; Scott and Turner, 1997). The frequency of single rooted second lower molars in North and South American native populations has been reported to range between 30% and 35% (Scott and Turner 1997). Frequency of such traits in the Maya region ranges between 15% and 30% (Jacobi, 2000; Wrobel, 2004; Cucina *et al.*, 2005).

From an endodontic perspective, single rooted lower second molars are described as C-shape, due to the pulp chamber morphology that appears as a "C" in the roots´ cross section (see Jafarzaed and Wu, 2007 for a review). Generally, the fused root is associated with the C-shape canal, even though the endodontic treatment that exposes the chamber cannot detect the actual morphology of the root.

The C-shape chamber morphology has been reported to be strongly associated with certain ethnic affiliations. High frequencies of C-shape second molars have been registered in Sinodont populations such as Chinese, Japanese and Koreans, while being relatively uncommon in Caucasoid or African peoples (Yang *et al.*, 1988; Habbad *et al.*, 1999; Gulabivala *et al.*, 2001; Seo and Park, 2004; Jin *et al.*, 2006; Jafarzaed and Wu, 2007). The Maya population's ancestry is Sinodont, yet the conquest has led to admixture with European and African populations in the region, likely altering the genetic (and morphological) structure of the population.

The goal of the present study is twofold: firstly, it aims at inferring the frequency of C-shape second molars in the Maya populations according to their ancestry in order to assess the continuity or discontinuity in the prevalence of this trait in the region in an evolutionary perspective; secondly, the actual correlation between root and canal form is measured in order to infer to what extent the single root (as a morphological trait) corresponds to a C-shape canal in its inner structure.

MATERIALS AND METHODS

The archeological sample consists of 48 mandibular second molars dated to the Classic period (250-800 AD), recovered from Xcambó and Noh Bec in northern Yucatán. They were selected randomly (Fig. 1); in most of the cases, the bony structure was missing or partly destroyed, so that the tooth had fallen out naturally. No tooth was extracted from its socket, since single rooted molars can be removed more easily than two-rooted ones, introducing a bias in its frequency. The one-rooted molars were then X-rayed to assess the shape of the

Correspondence to: Andrea Cucina, Facultad de Ciencias Antropológicas, Universidad Autónoma de Yucatán, Mérida, Km. 1 Carretera Mérida-Tizimín, 97305 Mérida, Yucatán, México
E-mail: acucina@yahoo.com

canal (Fig. 2). No archeological tooth was sectioned or partially destroyed to inspect the morphology of the inner chamber on ethical and legal grounds, as destructive analysis of archeological materials requires the permission of the Archeology Council under Mexican law. Once scrutinized, the teeth were returned to their own individual's storage boxes.

The modern sample consists of 142 second lower molars. It was registered by one of the authors (EVL) on patients attending the School of Endodontics of the Universidad Autónoma de Yucatán (UADY) for treatment during the fall semester of 2007. In this dental series, the form of the canal could be assessed visually from the occlusal surface (Fig. 3). X-rays were performed for every subject to provide additional information on the root morphology, even though this set of data could not be used directly in the present study.

Patients receiving treatment at the School of Endodontics of the UADY usually come from low income sectors of society. Relying on the subject's patient records, they are all of native origin and even though most of them were born in the town, their parents commonly originated in villages in northern Yucatán. Despite admixture, which makes any direct comparison to Prehispanic series problematic, this sample is largely representative of the natives' genetic background.

Fig. 1. Archeological example of a second mandibular molar from northern Yucatan, dated to the Classic period, which may possess a C-canal.

RESULTS

Among the 48 archeological roots under study, 17 were fused, constituting 35% of the total. Radiographic analysis revealed that 15 out of 16 individuals possessed a C-shape morphology in at least some parts of their root canal. One tooth was excluded because the X-ray did not permit inspection of the form of its chamber. The resulting ratio corresponds to 32% of the overall sample (15/47). The modern cohort represents a 29% of second lower molars with a C-shape canal (42/142). The difference between the archeological and modern sample is not significant (chi-square = 0.014; P = 0.905) (Table 1). As mentioned, no reliable information is available on the frequency of the one-rooted molar in the modern sample. We can assume that at least 42 out of 142 teeth were single-rooted; however, we cannot rule out the possibility that not all the one-rooted molars presented the C-shape. At the same time, two partly fused roots (forming a C-shape canal) may diverge towards the apical end. In anthropological terms, when the root is separated for at least one third of its length, it is considered as two roots.

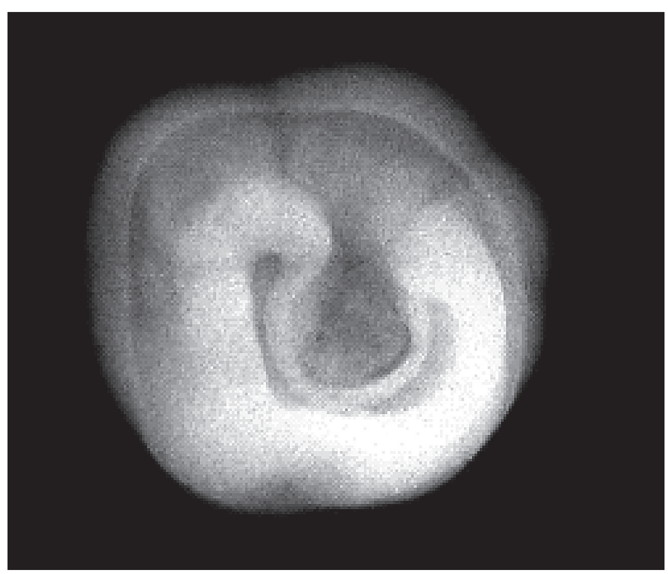

Fig. 2. X-ray image of the pulp chamber in an archeological second mandibular molar. The C-shape canal can be appreciated from the apical surface.

DISCUSSION

Genetic admixture (gene flow) is one of the reasons for changes in trait frequencies, and dental attributes are no exception. In opposition to other populations, like the Caribbean Tainos, who suffered a profound demographic collapse that led to its extinction within

TABLE 1. Counts and frequencies of C-shape canals and single-rooted second mandibular molars

Sample	Total	One-root	Frequency One-root	C-shape Count	C-shape Frequency
Prehispanic	48	17	35.4%	15	31.9%†
Modern	142	??	??	42	29.4%

†One single-rooted molar could not be scored for canal form.

few decades after the conquest (Rouse, 1963; Moya-Pons, 1982), the Maya became an integrated part of the newly formed, multi-ethnic society. The genetic admixture that occurred in Yucatan as a natural consequence of the European conquest and introduction of African slaves surely had an impact in the gene pool in the region. Here, demic movement also could have led to noticeable changes in the patterns of dental morphology. Jacobi (2000) reported that the greater morphological distance between historic Tipu and Historic Lamanai in Belize was likely the consequence of a major admixture of Mayas from northern Yucatán fleeing to Lamanai.

The present study has centered on just two traits. Clearly, it will be necessary to inspect a broader set of dental morphological traits in order to assess the extent to which admixture and time have modified the genetic structure of the modern Maya population compared to their Prehispanic status. This will be the goal of future studies.

Single-rooted second mandibular molars are very common in Maya populations, slightly less common in Europeans, and they appear to be rare in Africans (Scott and Turner, 1997). Since the frequency of fused roots in European groups is slightly lower than in Mesoamerican ones, admixture might not have led to profound changes in the modern sample. The frequency is very much lower in Africans (Scott and Turner, 1997). Specifically for sub-Saharan regions, from which the initial forced migration into the New World started in the 16th century AD, Irish (1997) reported a value of 7%. Even though African populations are considered to be the third root of the modern Mexican population (Tiesler *et al.*, 2008), their genetic contribution may not have been large enough to produce noticeable changes, at least not in the Yucatan region that has experienced a lower presence of African descendents than in neighboring states.

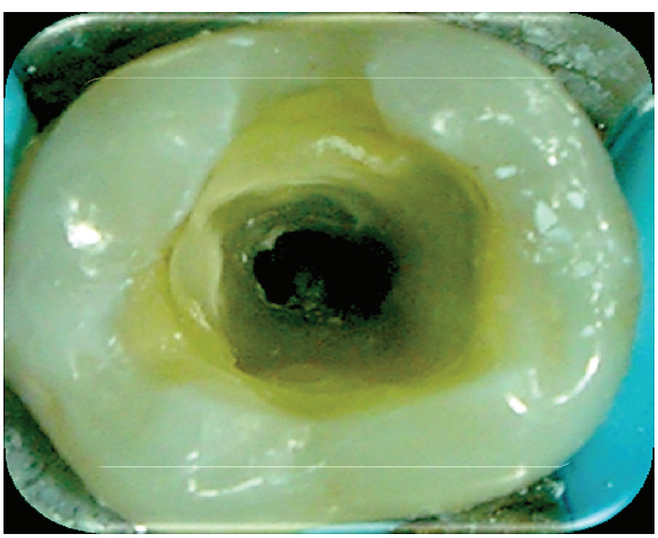

Fig. 3. Occlusal view of a C-shape root canal in a modern patient before being treated at the School of Endodontics, UADY. Mesial is to the right of the picture, and buccal is to the top.

Conversely, the distribution in canal shapes differs significantly between the Maya and Old World groups (Europe and Africa). C-shape root canals appear at comparable frequencies in the modern and Prehispanic Yucatecan population, while being uncommon in Old World groups (Jafarzaed and Wu, 2007). As a result of admixture, we were initially expecting a reduced frequency of "C" canals in the modern sample when comparing it to the Prehispanic series. It is puzzling, instead, that the frequencies are very much alike.

The form of the root canal is listed among dental anatomical anomalies (Jerome and Hanlon, 2007) and, at least until now, it does not seem to have specific evolutionary implications like other morphological traits that have been associated with dental reduction. Yet, the persistence of single-rooted second molars and, notably, the C-shape pulpal chamber in the modern series under study might indicate a genetic (or morphological) stability of this feature. Even though we stress the fact that a single trait is not sufficient to assess the extent of admixture, the persistence of this feature can be indicative of a persistent homogeneous composition of the modern Maya population in northern Yucatan.

Much remains to be done. From a joint anthropological and clinical perspective, the strong correlation between root form and canal morphology in the Prehispanic sample might be instrumental in understanding the occurrence of these traits in modern populations. The endodontic literature (see Jafarzaed and Wu's review, 2007) does not report the ethnic affiliation of those samples with low occurrence of C-shape canal. Given the extensive information on the C-shape canal in Asian peoples and the relative paucity in the other continents, further studies will shed light on this trait within the broader Mesoamerican sphere and in European and African groups.

ACKNOWLEDGEMENTS

We are grateful to Thelma Sierra Sosa, Xcambó Archaeological Project, and Agustín Peña Castillo, Noh Bec/El Escondidio Archaeological Project, for the archeological materials scrutinized in this study.

LITERATURE CITED

Cucina A, Tiesler V, Wrobel G. 2005. Afinidades biológicas y dinámicas poblacionales mayas desde el Clásico hasta el periodo colonial. Los Investigadores de la Cultura Maya 13: 559-567.

Gulabivala K, Aung TH., Alavi A, Ng YL. 2001. Root and canal morphology of Burmese mandibular molars. Int Endod J 34:359-370.

Haddad GY, Nehme WB., Ounsi HF. 1999. Diagnosis, classification and frequency of C-shape canals in mandibular second molars in the Lebanese population. J Endod 25:268-271.

Irish JD. 1997. Characteristic high- and low-frequency dental traits in sub-Saharan African populations. Am J Phys Anthropol 102:455-467.

Jabobi K. 2000. Last rites for the Tipu Maya: genetic structuring in a Colonial cemetery. Tuscaloosa: University of Alabama Press.

Jafarzadeh H, Wu YN. 2007. The C-shaped root canal configuration: a review. J Endodont 33:517-523.

Jerome CE, Hanlon RJ. 2007 Dental anatomical anomalies in Asians and Pacific islanders. CDA Journal 35:631-636.

Jin GC, Lee SJ, Roh BD. 2006. Anatomical study of C-shape canals in mandibular second molars by analysis of computed tomography. J Endodont 32:10-13.

Moya-Pons F. 1982. Los trabajadores indígenas y la estructura social en La Española en 1514. Boletín del Museo del Hombre Dominicano 17:119-133.

Rouse I. 1963. The Arawak. In: Steward JH, editor. Handbook of South American Indians. Vol 4. New Cork: Copper Square Publishers, p 507-546.

Scott GR, Turner CG II. 1997. The anthropology of modern human teeth. Cambridge: Cambridge University Press.

Seo MS, Park DS. 2004. C-shape root canals of mandibular second molars in a Korean population: clinical observation and in vitro analysis. Int Endod J 37:139-144.

Tiesler V, Zabala P, Cucina A, editors. 2008. Encounters at the Edge of the Sea. European, Maya and African Founders of Campeche, Mexico. Gainesville: University Press of Florida.

Turner CG II. 1990. Major features of Sundadonty and Sinodonty, including suggestions about East Asian microevolution, population history and Late Pleistocene relationships with Australian aboriginals. Am J Phys Anthropol 82:295-317.

Turner CG II, Nichol CR, Scott GR. 1991. Scoring procedures for key morphological traits of the permanent dentition: the Arizona State University dental anthropology system. In: Kelley MA, Larsen CS, editors. Advances in dental anthropology. New York: Wiley-Liss, p 13-31.

Yang ZP, Yang SF, Lin YC, Shay JC, Chi CY. 1988. C-shape root canals in mandibular second molars in a Chinese population. Endod Dent Traumatol 4:160-163.

Wrobel GD. 2004. Metric and non-metric dental variation among the ancient Maya of Northern Belize. Ph.D. dissertation, University of Indiana, Indiana.

Dental Nonmetric Traits in a Pre-Conquest Sample from Chubut Region of Patagonia, Argentina

Gabriel A. Bollini[1], Carlos David Rodríguez-Flórez[2], and Sonia E. Colantonio[3]

[1]*Cátedra de Antropología Biológica II, Facultad de Ciencias Naturales, Universidad Nacional de La Plata - Argentina*
[2]*Grupo de investigaciones ARQUEODIVERSIDAD, Universidad del Valle – Colombia, Departamento de Antropología y Sociología, Universidad de Caldas - Colombia*
[3]*Cátedra de Antropología Biológica y Cultural, Facultad de Ciencias Exactas, Físicas y Naturales, Universidad Nacional de Córdoba – Argentina, Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)*

ABSTRACT Dental morphological trait expressions have been used in anthropology and forensic sciences for determination of biological and geographical affiliations. The present study was carried out with a Chubut pre-conquest sample from Patagonia, Argentina. 18 skulls with partial dentitions from Chubut (Patagonia) were analyzed. The ASU Dental Anthropology System was used to register the expression grade of all dental traits. In spite of small sample sizes, we can conclude that shovel shape (UI1, UI2), two lingual premolar cusps (UP1, UP2), and hypocone (UM1, UM2) frequencies suggest a Mongoloid (Sinodont) origin. *Dental Anthropology* 2008;21(2):50-53.

Dental morphology has been used for determining biological and geographical affiliations. Dental variation has a heritable component, seems to be caused by multiple genes, and is little influenced by environmental factors (Rodríguez-Florez *et al*., 2006). Dental morphology can provide insights into phenotypic group differences, and these may be suggestive of differences in genotypic affiliation (Varela and Cocilovo, 2000). Nonmetric dental traits seem to be controlled in part by genetics and are relatively free of sex- and age-bias (Scott and Turner, 1997). The analysis of biological relatedness using dental nonmetric traits has been helpful even in commingled samples when standardized procedures are followed (Ullinger *et al*., 2005). For these reasons, reconstruction of biological relationships among ancient human groups using teeth is an important research problem for South American bioarcheologists.

The present study was carried out with a Chubut human pre-conquest sample from Patagonia, Argentina, with the aim of exploring dental morphological dental patterns in this group (Fig. 1). Researchers describe the people of this region as a group of aboriginal populations named Chonik or Patagones del Sur (Tehuelches). These natives use an aboriginal dialect with "Tchon" linguistic affiliation (Canals Frau, 1953). The objective of this article is to describe the presence of 40 dental nonmetric traits in this pre-conquest sample from the Chubut.

MATERIALS AND METHODS

Pre-conquest human dental remains with reasonably reliable stratigraphic contexts are relatively rare from Argentina. Marcellino and Colantonio (2000) suggest a Late Period between 0 and 1,500 A.D for the present sample. The sample belongs to División de Antropología del Museo de Ciencias Naturales (La Plata, Argentina), and it is composed of 18 skulls with partial dentitions from Chubut: 1041, 1057, 1060, 1081, E1837, 1083, 1117, 1119, 1165, 1167, 1837, 1067, E1844, 1139, 1167, 1140, 1047, CR (Museum Catalogue references). Forty (40) dental nonmetric traits were recorded using the ASU Dental Anthropology System to register the expression grade of all dental traits (Turner *et al*., 1991). Recording all of the dental traits was difficult because of environmental issues such as antemortem tooth loss, missing mandibles, postmortem fractures, and pathologies (Fig. 2). Consequently, a dichotomous recording system was used, grouping grade expressions into either "presence" (1) or "absence" (0).

RESULTS

Trait frequencies are listed in Table 1. It was impossible to adequately score three of the traits, namely paraconule (UM1) and the entoconulid (LM1, LM2). Values exceeding 70% were found for six traits—all in the upper arcade; these are shovel shape (UI1, UI2), two

Correspondence to: Carlos David Rodríguez-Flórez, Grupo de Investigaciones ARQUEODIVERSIDAD, Universidad del Valle - ColombiaDepartamento de Antropología y Sociología, Universidad de Caldas - Colombia
E-mail: bioarqueologia@ucaldas.edu.co

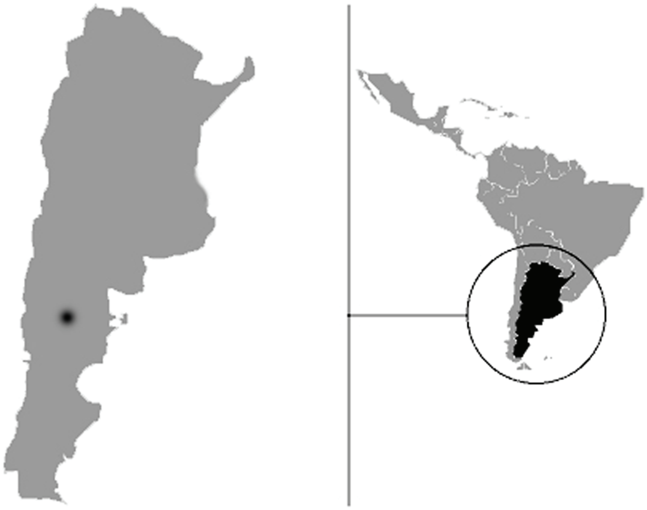

Fig. 1. Map of the Chubut region of Argentina..

lingual premolar cusps (UP1, UP2), and hypocone (UM1, UM2). Traits with frequencies between 10 and 69% were found for 12 traits: shovel shape (LI1, LI2, UC, LC), double shovel (UI1, UI2), tuberculum dentale (UI1, UI2, UC), interruption groove (UI2), two lingual premolar cusps (LP2), and metaconulid (LM1). The remaining 19 traits did not occur in the sample: double shovel (UC, LI1, LI2, LC), tuberculum dentale (LI1, LI2, LC), interruption groove (UI1, LI1, LI2), two lingual premolar cusps (LP1), Carabelli trait (UM1, UM2), paraconule (UM2), metaconule (UM1, UM2), metaconulid (LM2), and protostylid (LM1, LM2).

DISCUSSION

For Argentinean pre-conquest samples, previous studies by Devoto and co-workers describe high frequencies of shovel shape in the maxillary incisors in early Atacama Indians (1968), pre-columbian Tastilian indians (1971), and a Northwestern Argentinean group from Salta Province (1968). Devoto describes shovel shape (UI1) in 13 specimens studied at 100%. The high prevalence of dental shoveling is considered a prime component of the Mongoloid dental complex (Hanihara, 1968). For Devoto, in spite of his small samples, the data seem to be consistent enough to suggest that the specimens showed well-defined shovel-shaped maxillary incisors similar to well-typified Mongoloid races (DeVoto, 1971).

Fig. 2. Upper arcade of a Chubut skull (specimen 1083).

Pre-conquest samples from Tastil Region have shown similar distributions of some non-metric dental traits as double shovel shape UI2 (0.10), and tuberculum dentale UC (0.31) (Bollini *et al*., 2008). Comparably, the sample of Araucanos ethnic group exhibit similar distributions of shovel shape UI1 (0.85), and UI2 (0.71), double shovel shape UI1 (0.14), lingual cusp number UP1 and UP2 (1.00), hypocone UM1 (0.83), and metaconulid (0.11) (Bollini *et al*., 2007). These simple frequency comparisons are helpful in reinforcing the idea of early Sinodont-Mongoloid ancestral groups in this region of Argentina. The frequency of shoveling in the Chubut sample studied here is near to these values, again suggesting a Sinodont pattern.

The use of morphological traits can involve problems of a methodological nature with small archeological samples. A necessary assumption is that dental trait expression is morphologically symmetrical between homologous teeth. In bioarcheology, estimating the frequency of a dental trait is influenced by the availability of samples due preservation, crown wear, and caries (Rodriguez-Florez and Colantonio, 2007). Some authors recommend scoring the higher grade of expression for each dental trait (Turner and Scott, 1977) or counting both the left and right sides for each individual (Haeussler *et al*., 1988).

The present investigation provides additional information for population dynamics that can help us infer the possible biological factors in the process of South American peopling into regional and temporal ranges on ancient Patagonia, Argentina (Marcellino, 2002).

ACKNOWLEDGEMENTS

We wish acknowledge to Cecilia Ferreira by helping in recording and laboratory assistance. This article is in memory of Dr. Jorge Eduardo Bollini (R.I.P.); see key references (Bollini *et al*. 2006, 2007, 2008).

REFERENCES CITED

Bollini GA, Rodríguez-Flórez CD, Colantonio SE, Mendez MG. 2006. Antropología Dental de una serie prehistórica de araucanos provenientes de la Patagonia Argentina. Revista de Arqueología

TABLE 1. Dental nonmetric frequencies in the sample

Tooth type	Trait	Dichotomy	Presence	Absence	k/n	Frequency
		Maxillary Dentition				
UI1	Shovel shape	0 - 3	1 - 3	0	10/11	0.90
	Double shovel	0 - 4	1 - 4	0	3/11	0.27
	Tuberculum dentale	0 - 3	1 - 3	0	4/11	0.36
	Interruption groove	0 - 1	1	0	0/11	0.00
UI2	Shovel shape	0 - 3	1 - 3	0	9/10	0.90
	Double shovel	0 - 4	1 - 4	0	1/9	0.11
	Tuberculum dentale	0 - 3	1 - 3	0	4/10	0.40
	Interruption groove	0 - 1	1	0	2/11	0.18
UC	Shovel shape	0 - 3	1 - 3	0	3/7	0.42
	Double shovel	0 - 4	1 - 4	0	0/10	0.00
	Tuberculum dentale	0 - 3	1 - 3	0	2/10	0.20
UP1	Lingual cusp number	1 - 3	2 - 3	1	11/11	1.00
UP2	Lingual cusp number	1 - 3	2 - 3	1	9/9	1.00
UM1	Hypocone	0 - 3	1 - 3	0	7/7	1.00
	Carabelli complex	0 - 4	1 - 4	0	0/7	0.00
	Paraconule	0 - 1	1	0	-/-	-
	Metaconule	0 - 1	1	0	0/1	0.00
UM2	Hypocone	0 - 3	1 - 3	0	10/10	1.00
	Carabelli complex	0 - 4	1 - 4	0	0/9	0.00
	Paraconule	0 - 1	1	0	0/4	0.00
	Metaconule	0 - 1	1	0	0/6	0.00
		Mandibular Dentition				
LI1	Shovel shape	0 - 3	1 - 3	0	1/6	0.16
	Double shovel	0 - 4	1 - 4	0	0/6	0.00
	Tuberculum dentale	0 - 3	1 - 3	0	0/6	0.00
	Interruption groove	0 - 1	1	0	0/6	0.00
LI2	Shovel shape	0 - 3	1 - 3	0	3/8	0.37
	Double shovel	0 - 4	1 - 4	0	0/7	0.00
	Tuberculum dentale	0 - 3	1 - 3	0	0/7	0.00
	Interruption groove	0 - 1	1	0	0/8	0.00
LC	Shovel shape	0 - 3	1 - 3	0	2/7	0.28
	Double shovel	0 - 4	1 - 4	0	0/9	0.00
	Tuberculum dentale	0 - 3	1 - 3	0	0/9	0.00
LP1	Lingual cusp number	0 - 3	1 - 3	0	0/8	0.00
LP2	Lingual cusp number	0 - 3	1 - 3	0	4/8	0.50
LM1	Entoconulid	0 - 1	1	0	-/-	-
	Metaconulid	0 - 1	1	0	1/4	0.25
	Protostylid	0 - 1	1	0	0/10	0.00
LM2	Entoconulid	0 - 1	1	0	-/-	-
	Metaconulid	0 - 1	1	0	0/2	0.00
	Protostylid	0 - 1	1	0	0/9	0.00

Americana. Instituto Panamericano de Geografía e Historia (Mexico) 23:385-406.

Bollini GA, Rodríguez-Flórez CD, Colantonio SE, Mendez MG. 2007. Morfología dental de una serie prehistórica de araucanos provenientes de la Patagonia argentina y su relación biológica con otras poblaciones prehistóricas argentinas y del mundo. Int J Morphology, Sociedad Chilena de Anatomía (Chile) 24:705-712.

Bollini GA, Rodríguez-Flórez CD, Colantonio SE. 2008 Dental non-metric traits in a pre-conquest sample from Tastil region in Argentina, South America. Bull Int Assoc Paleodont 2:19-25.

Canals Frau S. Las poblaciones indígenas de la Argentina. Editorial Hyspamerica, 1953.

DeVoto FCH 1971. Shovel-shaped incisors in pre-columbian Tastilian indians. J Dent Res 50:168.

DeVoto FCH, Arias NH, Ringuelet S, and Palma NH. 1968. Shovel-shaped incisors in a northwertern argentinean population. J Dent Res 47:820-823.

Haeussler AM, Turner CG II, Irish JD. 1988. Concordance of American and Soviet methods in dental anthropology. Am J Phys Anthropol 75:218.

Hanihara K. 1968. Mongoloid dental complex in the permanent dentition. Proc. VIIIth Internat Congress Anthropol Ethnol Sci I:293-300.

Marcellino AJ, Colantonio SE. 2000. Los cráneos aborígenes más antiguos de la Argentina: un ensayo clasificatorio. Tendencias actuales de la Investigación en la Antropología Física Española p 205-218.

Marcellino AJ. 2002. Los procesos de adaptación en el poblamiento aborigen de Sudamérica. Anales de la Academia Nacional de Ciencias de Buenos Aires, p 9-26.

Rodriguea-Florez CD, Colantonio SE. 2007. Bilateral asymmetry of upper permanent dentition in six archaeological pre-conquest samples from Colombia, South America. Dental Anthropology 20:14-18.

Rodriguez-Florez CD, Fonseca GM, Villalba MT. 2006. Brief communication: Occurrence of an eighth cusp on primary second mandibular molars of a contemporary Argentinean child. Dental Anthropology 19:73-75.

Scott GR, Turner CG II. 1997. The anthropology of modern human teeth: dental morphology and its variation in recent human populations. Cambridge: Cambridge University Press.

Turner CG II, Scott GR. 1977. The dentition of Easter Islanders. In: Dahlberg AA, Graber TM, editors. Orofacial growth and development. The Hague: Mouton, p. 229-249.

Turner II CG, Nichol CR, Scott GR 1991. Scoring procedures for key morphological traits of the permanent dentition: The Arizona State University Dental Anthropology System. In: Kelley MA, Larsen CS, editors. Advances in dental anthropology. New York: Wiley-Liss Inc., p 13-31.

Ullinger JR, Sheridan SG, Hawkey DE, Turner II CG, Cooley R. 2005. Bioarchaeological analysis of cultural transition in the southern Levant using dental nonmetric traits. Am J Phys Anthropol 128:466-476.

Varela HH, Cocilovo JA. 2000. Structure of the Prehistoric population of San Pedro de Atacama. Curr Anthropol 41:125-132.

Congenital Absence of Permanent Canines: Report of Two Cases

Ann S. Smith* and Edward F. Harris

Department of Pediatric Dentistry, University of Tennessee, Memphis

ABSTRACT Congenital absence of permanent canines is a rare event, especially when syndromic cases are excluded. Our data suggest a population frequency of roughly 1 per 1,000 people. This report describes two contemporary cases with radiographically-confirmed bilateral absence of the maxillary canines. One is a case of simple hypodontia, where only the upper canines failed to develop (though the lateral incisors are under-size). The other case exhibits the additional absence of maxillary lateral incisors and second premolars. These cases add weight to prior findings that (A) the canine is the tooth type least likely not to form, (B) upper canines are more likely to be missing than mandibular canines, and (C) the frequency is higher in females than males. *Dental Anthropology* 2008;21(2):54-59.

Most people develop all 32 permanent teeth, but the congenital absence of one or more of these teeth is not uncommon (Pindborg, 1970). Indeed, no tooth type is immune to failure-to-form, though some tooth types, notably the maxillary lateral incisor and second premolars are comparatively likely to experience congenital absence (Egermark-Eriksson and Lind, 1971; Mattheeuws *et al*., 2004). On the other hand, canines are renowned for their developmental stability; canines are the teeth least likely to be congenitally absent (Polder *et al*., 2004).

The population incidence of missing canines is hard to determine accurately because of variations among studies in selection criteria (*e.g.*, whether syndromes are included), sampling fluctuations, and whether absence is verified radiographically (so failures of eruption can be distinguished from failure of formation).

The purpose of this report is to describe two contemporary clinical cases that are unusual in that both permanent canines are missing from one arch. There appears to be little effect of this rare form of hypodontia on the other teeth in one case, while the other case has additional missing teeth.

Case Discovery

One case (KP) was identified during a systematic review of orthodontic patients (Harris and Clark, 2008). These were "phenotypically normal" cases, where those with syndromes or other conditions known to enhance the risk of hypodontia had been culled. Exempted conditions included clefts of the lip and palate, hypohidrotic ectodermal dysplasia (Itin and Fistarol, 2004), and cases probably due to Pax9 or Msx1 (or similar major genes) that cause oligodontia (Mostowska *et al*., 2003; Vieira, 2003; Larmour *et al*., 2005). The second case (LS) was encountered during routine treatment in a pediatric dental clinic and was referred to the authors for consultation.

Both cases were free of any identifiable developmental problem aside from the isolated hypodontia, though they were not tested genetically.

Case KP

This is a 15-7 year-old American black female (Fig. 1) who presented to the Department of Orthodontics with the major complaint that she disliked the space (*ca*. 5 mm) between her maxillary central incisors. She herself was unaware that her canines were congenitally absent. Indeed, given the high incidence of impacted maxillary canines (*e.g*., Bishara, 1998; Richardson and Russell, 2000), their absence on initial visual inspection was not surprising; the orthodontist assumed at first that they were merely impacted. On radiographic examination, their absence was confirmed, though all 30 of the other permanent teeth were present. All four third molars appear to be eumorphic on X-ray.

Absence of the canines had led to lateral migration of the incisors, with interdental spacing, notably development of the midline diastema (Fig. 1). This recalls Moorrees' (1959) finding (and those of Baume (1950) and others) that the mesially-canted eruption paths of the canines promote consolidation of the

Correspondence to: Ann S. Smith, Department of Pediatric Dentistry, University of Tennessee, Memphis, Tennessee U.S.A. 38163
E-mail: ASMIT138@utmem.edu

Fig. 1. Panoramic radiograph of case KP. All of the permanent teeth, including the 4 third molars, are mineralizing. Congenital absence is limited to the left and right maxillary canines.

incisors and, perhaps, lead to incisor crowding at this stage. It seems that, without the canines, incisors in the anterior segment remain spaced.

Overjet and overbite were both near-zero; indeed, there are small wear facets on some of the incisors where they occluded end-on. The maxillary left lateral incisor was in crossbite. The other obvious occlusal issue was that the mandibular right canine was displaced to the lingual while the adjacent first premolar was displaced to the buccal. One conjecture is that this premolar's eruption was diverted out of the arch form because of early loss of arch space that should have been retained by the deciduous canine and first molar in that quadrant (*cf*. Stefan, 2006).

Absence of the canines and asymmetric loss of primary teeth led to an asymmetric arch form (more obvious in the maxilla), where the buccal teeth on the right side are positioned farther mesially. This translated into a Class I buccal segment relationship on the left and an end-on Class II relationship on the right (*cf*. Harris and Corruccini, 2008).

The maxillary right deciduous canine had exfoliated some time ago, and mesial drift of the premolars and molars in that quadrant closed the space, so the first premolar was abutted against the lateral incisor. The deciduous canine on the left exfoliated quite recently, and a 9 mm space occurred behind the lateral incisor on that side when the pretreatment orthodontic records were taken.

Obvious orthodontic treatment options were either (1) to open the canine spaces for osseointegrated single-tooth implants (*e.g.*, Higuchi, 2000) or (2) to close the spaces, substituting (and recontouring) the first premolars to function as the canines. The latter course was chosen here, which required that the mandibular first premolars be extracted as part of treatment to achieve proper interdigitation between the jaws.

It is evident on inspection that, while all 30 teeth are present in this case (Figs. 1, 2), the maxillary lateral incisors are undersize: The right lateral incisor is small

Fig. 2. Intraoral photographs of case KP. The missing maxillary canines are thought to contribute to the tapered arch form and the interdental spacing, particularly the maxillary midline diastema. The maxillary lateral incisors are undersize, notably in the subject's right quadrant. Premolar displacements (upper left and lower left quadrants) likely are due to early loss of primary teeth, though there is no solid dental history for this case.

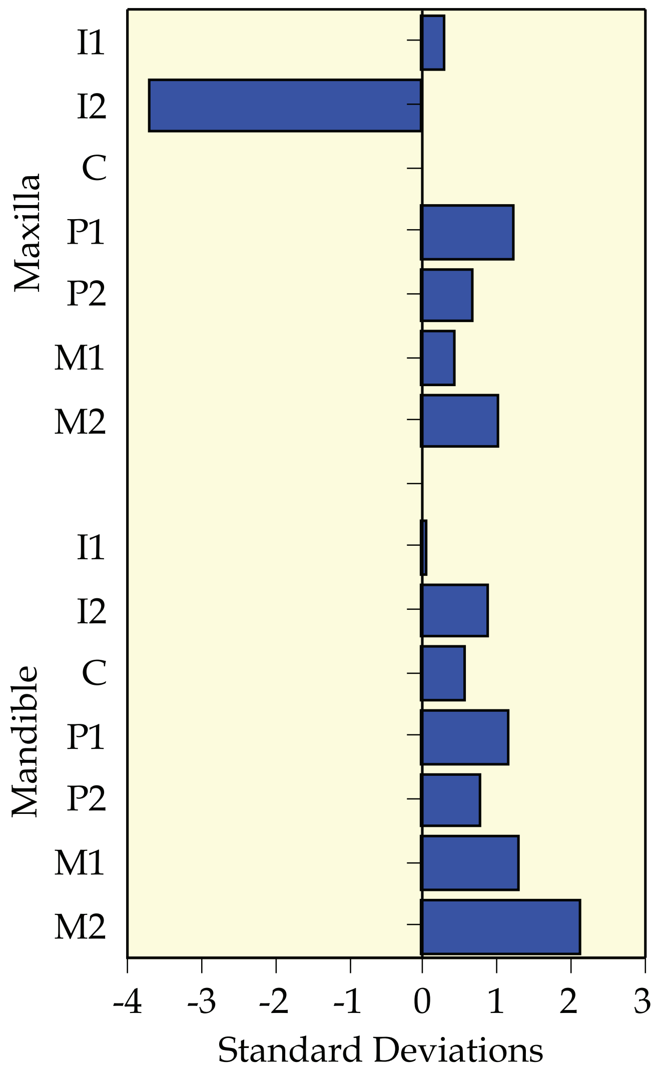

Fig. 3. Bar chart of the mesiodistal crown dimensions of case KP, expressed as z-scores. Aside from the small maxillary lateral incisors, all other tooth types are of at least normal size, suggesting that congenital absence of the canines is an anatomically localized, not a systemic problem, in this girl. The reference sample used here for comparison is the group of African American girls decscribed by Richardson and Malhotra (1976).

mesiodistally (7.0 mm) and the left lateral incisor is pegged with an essentially circular cross section (5.0 mm). The mesiodistal crown dimensions of this case are graphed as z-scores (standard deviation units) in Fig. 3. Aside from the undersize maxillary lateral incisors just mentioned, none of the other tooth types is noteworthy; in fact, most dimensions are slightly above the average.

Case LS

The second case is a healthy American white female referred for consultation. The panoramic radiograph, taken at age 9-1 years (Fig. 4), reveals a mixed dentition with congenital absence of at least six permanent teeth (third molars not yet discernible). Specifically, there is bilateral absence of the permanent maxillary lateral incisors, canines, and second premolars. At this chronological age, third molar crypt formation often is evident (*e.g.*, Rantanen, 1967), but not in this girl. History also revealed congenital absence of the primary maxillary lateral incisors. This recalls the developmental issue that, when a primary tooth is congenitally absent, most times the successor also will be absent because the permanent tooth bud branches off from its predecessor—so absence of a primary tooth often foretells absence of its permanent replacement tooth (*e.g.*, Avery, 1994).

Evaluation disclosed variability of developmental stages among the molar types. The development of the second maxillary right molar appears questionable (Fig. 4).

Studies suggest that tooth development is delayed in cases of hypodontia (Uslenghi *et al*. 2007). Using the Demirjian standards for tooth development (Demirjian *et al*., 1973) that we have adapted for the local population, this girl has a dental age of 5.9 years, which is delayed by 35% compared to her chronological age of 9.1 years.

Mesial drift of the maxillary first premolars into the sites of the canines is evident on the panoramic radiograph (Fig. 4). As well, there has been lateral drift of the central incisors that has established a prominent midline diastema. Lower anterior crowding also is evident. The malocclusion was treatment planned for serial extractions of the primary teeth and extraction of the mandibular first premolars. Age-appropriate maxillary anterior implants are included in the treatment plan to be placed when the bulk of the girl's facial growth is completed.

Hypodontia

The two cases described here are unusual in that congenital absence of permanent canines is rare, notably so in cases of simple hypodontia (in contrast to cases with oligodontia; Schalk-van der Weide, 1992). In a systematic review of adolescent cases with hypodontia (Harris and Clark, 2008), only 1 case of missing permanent canines was found in the sample of 1,600, yielding a frequency of 0.06%. Of note, this study excluded craniofacial syndromes and cases with oligodontia. This frequency is the same order of magnitude as reported by Dolder (1937) at 0.06% and by Bergström (1977) at 0.23%. A recent study by Fukuta and coworkers (2004) identified 65 cases of congenitally missing permanent canines in their review of 35,927 dental patients (0.18%), but this included cases of complex hypodontia. Large studies such as this suggest that canine hypodontia (A) is more common in females than males, (B) is more common in the maxilla than the mandible, and (C) tends to be associated with hypodontia of other permanent teeth

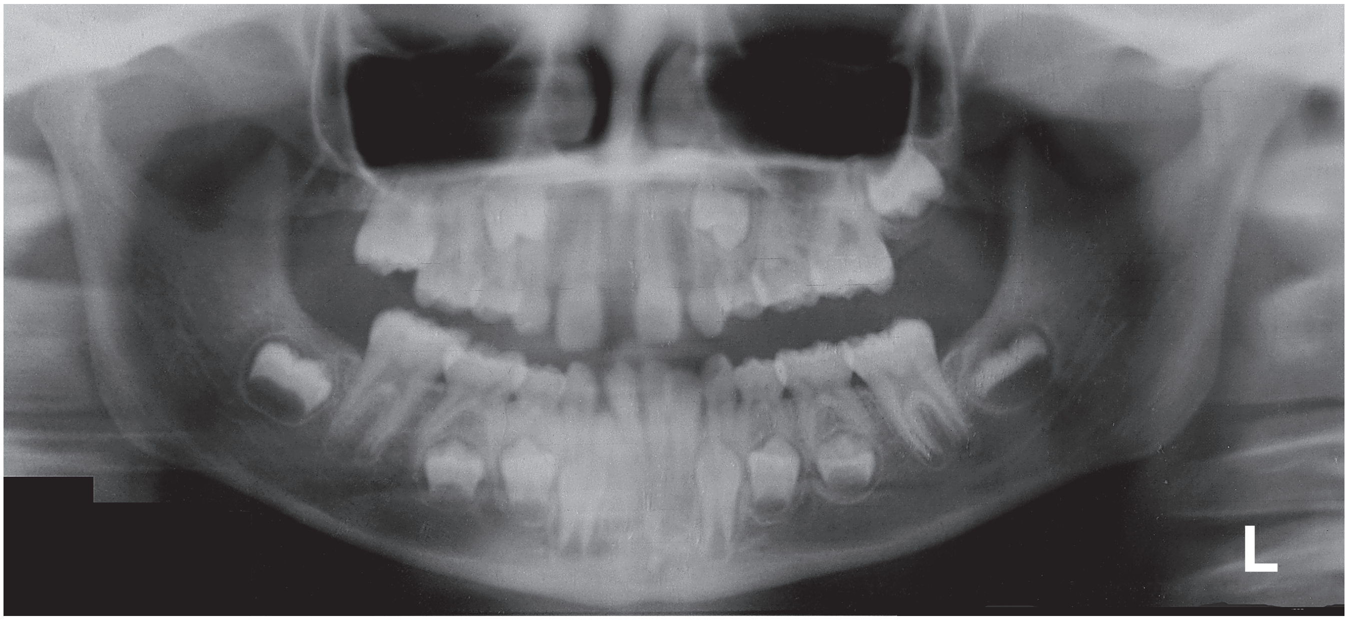

Fig. 4. Panoramic radiograph of case LS. Both maxillary canines are congenitally absent, as well as the lateral incisor and the second premolar in both maxillary quadrants. The other teeth are of normal size and morphology, though the girl is too young to know whether the third molars will develop. Notice, too, that it is uncertain whether the maxillary right second molar is forming; in any event it is appreciably delayed relative to the three other second molars. There is no third molar crypt formation in this girl (9-1 years). The developing maxillary first premolars are rotated (so both the lingual and buccal cusps are readily evident), but this is not particularly unusual.

(particularly maxillary lateral incisors, mandibular central incisors, and premolars).

Failure of a tooth's formation can occur at any of several steps during odontogenesis. Perhaps the most obvious situation is where the molecular signal from the ectoderm to the underlying mesoderm (dental lamina) fails to occur, so there is no initiation of bud formation, though the specific causes do not seem to be known. Formation also might cease when reciprocal signaling from the mesenchyme back to the ectoderm is lacking (*e.g.*, Peters *et al.*, 1998).

Formation also may cease during bud formation and, thus, before the initiation of mineralization (Harris, 2002). This has been documented in mice, rats, and rabbits. These animals do not possess lateral incisors (nor canines, nor premolars). However, careful histological study (Fitzgerald, 1973; Moss-Salentijn, 1978) discloses that lateral incisors begin formation, but development ceases in the bud stage, presumably because signaling to promote morphodifferentiation is lacking.

Causes of tooth suppression (or interrupton of formation) probably differ among species (*e.g.*, Peterková *et al.*, 2002). In the mouse, sprouty genes (antagonists of fibrobast growth factor (FGF) signaling) suppress tooth formation in the incisor-to-molar diastema by inhibiting Shh (sonic hedgehog) in this region. The mode of action seems to be that Shh expression in the diastema inhibits FGF signaling from the mesenchyme (Klein *et al.*, 2006). Of course, the mechanism in humans—let alone in the cases described here—may be unrelated to this scenario, but the point is that tooth agenesis has its basis in some failure of chemical signaling to promote development.

Influences from the environment also need to be considered as influencing the risk of hypodontia (where the "environment" interrupts normal biochemical signaling). The conjecture is that greater environmental stress on an individual during tooth initiation increases the risk of hypodontia. "Anthropological" cases of "stressed" populations (*e.g.*, Bailit *et al.*, 1970) do not provide strong evidence of this because the level of stress is merely conjectured post hoc. We suggest that a more telling situation occurs in children treated for acute lymphocytic leukemia (*e.g.*, Kaste *et al.*, 1997). These children are otherwise normal, but have acute onset of leukemia that has to be treated aggressively with chemotherapy and/or cranial irradiation (Pui, 1999). Hypodontia consequent to irradiation is predictable because the formative cells are killed (Kaste and Hopkins, 1994). Notably, children treated with chemotherapy alone also have substantially greater frequencies of hypodontia (Weathersby, 2006). We interpret these cases as dramatic situations in which the environmental stressors (chemotherapy) can halt tooth development.

Harris and Hullings (1990) suggested a similar scenario for children with cleft of the lip and palate.

Hypodontia is appreciably higher in children with clefts (Böhn, 1963; Ranta, 1983, 1986), and Harris speculated that this is consequent to the cleft, with failure to thrive, recurrent middle ear and upper respiratory infections, the stress of repeated surgeries, and the like. The scenario—greater hypodontia in response to greater environmental stress—is still attractive, but it is considerably more speculative now that there is greater appreciation of a genetic basis for isolated (nonsyndromic) clefts (*e.g.*, Peters *et al*., 1998l; Satokata and Maas, 1994; Vieira, 2003; Zucchero *et al*., 2004).

Mutant forms of Pax9, Msx1, and Axin2, among other genes, have been documented to promote hypodontia (Cobourne, 2007; Matalova *et al*., 2008). These genes, however, have fairly dramatic effects—typically resulting in the congenital absence of multiple teeth. In part, this is because it has been technically easier to identify the familial effects of genes with dramatic effects on the phenotype. One supposes that other genes, with less severe and, thus, more common effects—such as the absence of single teeth ("simple hypodontia") will be identified with more refined studies in the future.

The Canine

Sadly, we offer no explanation for the symmetric congenital absence of permanent canines in the two cases described here. Although there is only one canine per quadrant, the canine rarely is absent, and its morphogenetic effects on adjacent teeth in terms of cingular morphology (Turner, 1969; Scott, 1977) and the extent of sexual dimorphism (Garn *et al*., 1977) are well documented.

The literature suggests that there is some familial aggregation of canine absence (*e.g.*, Postello, 1984; Huggare, 1984)—which might imply a genetic basis for some cases—but such case studies probably are over-reported since they are noteworthy. Alternatively, very few studies have explicitly studied hypodontia in sibships (as opposed to samples of biologically unrelated individuals), so an unbiased estimate of recurrence in families is unavailable.

OVERVIEW

Two cases of congenital absence of permanent maxillary canines are described. In one case, these are the only teeth that failed to form; in the other, maxillary lateral incisors and second premolars also were absent. Etiology of this rare condition remains speculative.

REFERENCES CITED

Avery JK, editor. 1994. Oral development and histolog, 2nd ed. New York: Thieme Medical Publishers, Inc.

Bailit HL, Workman PL, Niswander JD, MacLean CJ. 1970. Dental asymmetry as an indicator of genetic and environmental conditions in human populations. Hum Biol 42:626-638.

Baume LJ. 1950. Physiological tooth migration and its significance for the development of occlusion. II. The biogenesis of accessional dentition. J Dent Res 29:331-337.

Bergström K. 1977. An orthopantomographic study of hypodontia, supernumeraries and other anomalies in school children between the ages of 8-9 years. An epidemiological study. Swed Dent J 1:145-157.

Bishara SE. 1998. Clinical management of impacted maxillary canines. Semin Orthod 4:87-98.

Böhn A. 1963. Dental anomalies in harelip and cleft palate. Acta Odontol Scand Suppl 38:1-109.

Cobourne MT. 2007. Familial human hypodontia—is it all in the genes? Br Dent J 203:203-208.

Demirjian A, Goldstein H, Tanner JM. 1973. A new system of dental age assessment. Hum Biol 45:211-227.

Dolder E. 1937. Deficient dentition: statistical survey. Dent Record 57:142-143.

Egermark-Eriksson I, Lind V. 1971. Congenital numerical variation in the permanent dentition. D. Sex distribution of hypodontia and hyperodontia. Odontol Revy 22:309-315.

Fitzgerald LR. 1973. Deciduous incisor teeth of the mouse (*Mus musculus*). Arch Oral Biol 18:381-389.

Fukuta Y, Totsuka M, Takeda Y, Yamamoto H. 2004. Congenital absence of the permanent canines: a clinico-statistical study. J Oral Sci 46:247-252.

Garn SM. 1977. Genetics of tooth development. In: McNamara JA, editor. The biology of occlusal development. Ann Arbor, MI: Craniofacial Growth Series, p. 61-88.

Harris EF. 2002. Dental development and anomalies in craniosynostosis and facial clefting. In: Mooney MP, Siegel MI, editors. Understanding craniofacial anomalies: the etiopathogenesis of craniosynostosis and facial clefting. New York: John Wiley-Liss, p 425-467.

Harris EF, Clark LL. 2008. An epidemiological study of hyperdontia in American blacks and whites. Angle Orthod 78:460-465.

Harris EF, Corruccini RS. 2008. Quantification of dental occlusal variation: a review of methods. Dental Anthropology 21:1-11.

Harris EF, Hullings JG. 1990. Delayed dental development in children with isolated cleft lip and palate. Arch Oral Biol 35:469-473.

Higuchi KW. 2000. Orthodontic applications of osseointegrated implants. Chicago: Quintessence Publishing Company, Inc.

Huggare J. 1984. Congenital aplasia of four permanent cuspids: a case report. Proc Finn Dent Soc 80:257-259

Itin PH, Fistarol SK. 2004. Ectodermal dysplasias. Am J Med Genet C Semin Med Genet 131C:45-51.

Kaste SC, Hopkins KP. 1994. Micrognathia after radiation therapy for childhood facial tumors. Oral Surg Oral Med Oral Path 77:1:95-99.

Kaste SC, Hopkins KP, Jones D, Crom D, Greenwald CA, Santana VM. 1997. Dental Abnormalities in children treated for acute lymphoblastic leukemia. Leukemia 11:792-796.

Klein OD, Minowada G, Peterkova R, Kangas A, Yu BD, Lesot H, Peterka M, Jernvall J, Martin GR. 2006. Sprouty genes control diastema tooth development via bidirectional antagonism of epithelial-mesenchymal FGF signaling. Dev Cell 11:181-190.

Larmour CJ, Mossey PA, Thind BS, Forgie AH, Stirrups DR. 2005. Hypodontia—a retrospective review of prevalence and etiology. Part I. Quintessence Int 36:263-270.

Matalova E, Fleischmannova J, Sharpe PT, Tucker AS. 2008. Tooth agenesis: from molecular genetics to molecular dentistry. J Dent Res 87:617-623.

Mattheeuws N, Dermaut L, Martens G. 2004. Has hypodontia increased in Caucasians during the 20th century? A meta-analysis. Eur J Orthod 26:99-103.

Moorrees CFA. 1959. The dentition of the growing child. Cambridge: Harvard University Press.

Moss-Salentijn L. 1978. Vestigial teeth in the rabbit, rat and mouse; their relationship to the problem of lacteal dentitions. In: Butler PM, Joysey KA, editors. Development, function and evolution of teeth. London: Academic Press Inc, p 13-29.

Mostowska A, Kobielak A, Trzeciak WH. 2003. Molecular basis of non-syndromic tooth agenesis: mutations of MSX1 and PAX9 reflect their role in patterning human dentition. Eur J Oral Sci 111:365-370.

Peterková R, Peterka M, Viriot L, Lesot H. 2002. Development of the vestigial tooth primordia as part of mouse odontogenesis. Connect Tissue Res 43:120-128.

Peters H, Neubüser A, Kratochwil K, Balling R. 1998. Pax9-deficient mice lack pharyngeal pouch derivatives and teeth and exhibit craniofacial and limb abnormalities. Genes Dev 12:2735-2747.

Pindborg JJ. 1970. Pathology of the dental hard tissues. San Francisco: WB Saunders Company.

Polder BJ, Van't Hof MA, Van der Linden FP, Kuijpers-Jagtman AM. 2004. A meta-analysis of the prevalence of dental agenesis of permanent teeth. Community Dent Oral Epidemiol 32:217-226.

Postello DR. 1984. Congenitally missing maxillary canines: a report of two cases. Ont Dent 61:10-12.

Pui CH. 1999. Acute lymphoblastic leukemia. In: GR Lee. Wintrobe's clinical hematology. Baltimore: Williams & Wilkins, p 1141-1153.

Ranta R. 1983. Hypodontia and delayed development of the second premolars in cleft palate children. Eur J Orthod 5:145-148.

Ranta R. 1986. A review of tooth formation in children with cleft lip/palate. Am J Orthod Dentofac Orthop 90:11-18.

Rantanen AV. 1967. The age of eruption of the third molar teeth. Acta Odont Scand 25:1-86.

Richardson G, Russell KA. 2000. A review of impacted permanent maxillary cuspids—diagnosis and prevention. J Can Dent Assoc 66:497-501.

Richardson ER, Malhotra SK. 1975. Mesiodistal crown dimension of the permanent dentition of American Negroes. Am J Orthod 1975;68:157-164.

Satokata I, Maas R. 1994. Msx1 deficient mice exhibit cleft palate and abnormalities of craniofacial and tooth development. Nat Genet 6:348-356.

Schalk-van der Weide Y. 1992. Oligodontia: a clinical, radiographic and genetic evaluation. Utrecht: Rijksuniversiteit Utrecht.

Scott GR. 1977. Lingual tubercles and the maxillary incisor-canine field. J Dent Res 56:1192.

Stefan VH. 2006. Rotation of the maxillary premolars: evidence in support of premolar morphogenetic field. Dental Anthropology 70:19:70-82.

Turner CG 2nd. 1969. Directionality in the canine field model. J Dent Res 48:1310.

Uslenghi S, Liversidge HM, Wong FS. 2006. A radiographic study of tooth development in hypodontia. Arch Oral Biol 51:129-133.

Vieira AR. 2003. Oral clefts and syndromic forms of tooth agenesis as models for genetics of isolated tooth agenesis. J Dent Res 82:162-165.

Weathersby MG. 2006. Dental maturation in children treated for acute lymphoblastic leukemia. M.D.S. Thesis, University of Tennessee, Memphis.

Zucchero TM, Cooper ME, Maher BS, Daack-Hirsch S, Nepomuceno B, Ribeiro L, *et al*. 2004. Interferon regulatory factor 6 (IRF6) gene variants and the risk of isolated cleft lip and palate. N Engl J Med 351:769-780.

Constitution and By-Laws
Dental Anthropology Association

ARTICLE I: Name

The name of this organization shall be Dental Anthropology Association (DAA).

ARTICLE II: Objectives

The general nature, object, and purpose of this Association shall be for any and all of the following purposes:
- (a) For the exchange of educational, scientific and scholarly knowledge in the field of dental anthropology.
- (b) To stimulate interest in the field of dental anthropology.
- (c) To publish a journal, DENTAL ANTHROPOLOGY, the Official Publication of the Dental Anthropology Association.

ARTICLE III: Membership

Section 1. Membership in this organization shall be of two classes: (a) Regular and (b) Student.

Section 2. Those eligible for membership in this organization shall be persons who have an academic, research, and/or clinical interest in dental anthropology.

ARTICLE IV: Board of Directors

Section 1. The business of the Association shall be under the management of the Board of Directors, composed of the following elected officers: President, President-Elect, Secretary-Treasurer, Editor of DENTAL ANTHROPOLOGY, and one Executive Board Member. The Board will also have one student member, selected by a combined decision of the President, President-Elect, and Secretary-Treasurer.

Section 2. The Board of Directors shall meet annually, exceptions to be determined by the President.

Section 3. Special meetings may be called by the President.

Section 4. A quorum will consist of those members present.

Section 5. The elected officers of the Association shall constitute the Executive Committee, which may meet to consider any important matters which may arise between meetings of the Association. Every member of the Executive Committee having been notified of meeting, those present shall constitute a quorum.

Section 6. Members of the Association may attend the Board of Directors Meetings and may vote. They may have the privilege of the floor by consent of the presiding officer.

ARTICLE V. Officers and Elections

Section 1. Designation of officers. The elected officers of this organization shall be the President, President-Elect, Secretary-Treasurer, Editor of DENTAL ANTHROPOLOGY, and one Executive Board Member. The President, president-Elect, and Secretary-Treasurer shall serve for a period of two years, the Executive Board member for a period of three years, and the Editor of DENTAL ANTHROPOLOGY for a period of four years. The student member will serve for a term of three years or until his graduation or otherwise ceasing to be a full-time student.

Section 2. The slate of incoming officers shall be presented by the Nominations-Elections officer to the general membership before the Annual Meeting.

Section 3. Nominations may be made from the general membership at the Annual Meeting.

Section 4. If there is more than one nominee for an office, election shall be secret ballot counted by the Secretary-Treasurer. In case of a tie the President shall cast the deciding vote. If only one nominee is presented for an office, that office may be filled by instruction from the floor to have the Secretary-Treasurer cast a unanimous vote for such nominee.

Section 5. Vacancies among officers may be filled by vote of the remaining members of the Board of Directors.

ARTICLE VI: Duties of officers

Section 1: President:

(a) Shall preside at all general membership Annual Meetings and Board Meetings.
(b) Shall be an ex-officio member of all standing and special committees.
(c) Shall appoint the chairs of all standing and special committees.
(d) Shall serve as a liaison officer between the Association and other professional organizations.

Section 2: President-Elect:

(a) Shall assume the office of President following the term of President.
(b) Shall stand in and assume the duties for the President in the event that the President is not able to perform his or her duties.

Section 3: Secretary-Treasurer:

(a) Shall assist the President in the discharge of his or her duties.
(b) Shall keep the minutes of meetings of the Board of Directors and general membership Annual Meetings and submit them for approval. A copy of such minutes shall be sent to the President within ten days of the meeting.
(c) Shall keep an accurate roll call of each Board Meeting.
(d) All reports of officers and committees shall be filed with the Secretary-Treasurer for record.
(e) Shall conduct the official correspondence of the Association under the direction of the President.
(f) Shall be the custodian of all funds of the Association, which he or she shall disburse only on order of the Board of Directors. All bills must be accompanied by an itemized statement or receipt when reimbursement is in order.
(g) Shall send dues statements to all eligible members.
(h) Shall submit a regular written report at each Board Meeting, and at the general membership Annual Meeting shall present a full and written report of the finances of the Association.
(i) Shall file all appropriate federal, state, and local forms according to law.

Section 4. Editor of DENTAL ANTHROPOLOGY:

(a) Shall publish DENTAL ANTHROPOLOGY.

Section 5. Executive Board Member:

(a) Shall serve as Nominations-Elections Officer, Program Chair, and Meeting Facilitator.

ARTICLE VII: Committees

Section 1. Standing committees may be established at the discretion of the President.

Section 2. Special committees may be created by the Board of Directors to perform the special function for which they are so created. The Chair of such committees shall be appointed by the President.

ARTICLE VIII: Meetings

Section 1. Unless otherwise ordered by the Association or the Board of Directors, regular meetings shall be held annually.

Section 2. Special meetings may be called by the President with the consent of the Board of Directors, with adequate notification of the membership.

Section 3. The annual meeting shall be designated as the Annual Meeting of the Dental Anthropology Association, held in conjunction with the American Association of Physical Anthropologists.

ARTICLE IX: Dues and Finance

Section 1. Dues:

(a) To be included in the membership of the Association and receive a subscription to DENTAL ANTHROPOLOGY, dues must be paid by January 31 of the current fiscal year.

(b) Dues of this organization shall be set by the Board of Directors with the approval of the general membership. The membership shall be notified of the proposed change at the Annual Meeting.

Section 2. Finance:

(a) The Finance Committee shall consist of the Board of Directors.

(b) The Finance Committee shall present a proposed budget to the membership for approval at the Annual Meeting.

(c) The disbursement of monies not provided for in the budget shall be voted upon at the Annual Meeting.

(d) The signature of the President and the Secretary-Treasurer shall be on record at the depository and either signature is valid for all banking transactions.

Section 3. The fiscal year shall be from June 1 of one year through May 31 of the following year.

ARTICLE X. Amendments and Rules of Order

Section 1. The By-Laws may be revised or amended at any meeting of the general membership by a two-thirds vote of those present and eligible to vote, the proposed amendments or revisions having been mailed to the general membership thirty (30) days prior to the date the vote is to be taken.

Section 2. Robert's Rules of Order, Newly Revised, shall be the parliamentary authority for all matters of procedures not specially covered by the By-Laws of this organization.

ARTICLE XI: Dissolution of the Dental Anthropology Association

No persons shall possess any property right in or the property or assets of the Association. Upon dissolution of the corporation, and after all obligations are satisfied, all assets shall be distributed exclusively to the American Association of Physical Anthropologists.

Editor's Note:

These By-Laws have been updated based on amendments passed at the Annual Meeting, 2008.

RESEARCH COMPETITION in DENTAL ANTHROPOLOGY

THE ALBERT A. DAHLBERG PRIZE

The Albert A. Dahlberg Prize is awarded annually to the best student paper submitted to the *Dental Anthropology Association* (*DAA*). Dr. Dahlberg was a professor at the University of Chicago, one of the founders of the International Dental Morphology Symposia, and among the first modern researchers to describe variations in dental morphology and to write cogently about these variations, their origins, and importance. The prize is endowed from the Albert A. Dahlberg Fund established through generous gifts by Mrs. Thelma Dahlberg and other members of the association.

Papers may be on any subject related to dental anthropology. The recipient of the Albert A. Dahlberg Student prize will receive a cash award of $200.00, a one-year membership in the Dental Anthropology Association, and an invitation to publish the paper in *Dental Anthropology*, the journal of the association.

Students should submit three copies of their papers in English to the President of the *DAA* (*below*). Manuscripts must be received by January 31 of the year that the prize will be awarded, in this case January 31, 2009. The format must follow that of *Dental Anthropology,* which effectively the style of the *American Journal of Physical Anthropology*. The Style Guide to Authors also is available at the web site for the *AJPA* (http://www.physanth.org).

The manuscript should be accompanied by a letter from the student's supervisor indicating that the individual is the primary author of the research and the paper. Multiple authorship is acceptable, but the majority of the research and writing must be the obvious work of the student applying for the prize. Send enquiries and submissions to the President of the *DAA*:

Professor Brian E. Hemphill
Department of Sociology and Anthropology
9000 Stockdale Highway
California State University, Bakersfield
Bakersfield, California 93311-1099 U.S.A.
e-mail: bhemphill@csub.edu

The *DAA* reserves the right to select more than one paper, in which case the prize money will be shared equally among the winners. They also reserve the right to not select a winner in a particular year.

The winner of the Albert A. Dahlberg Student Prize will be announced at the Annual Meeting of the *DAA*, which is held in conjunction with the annual meeting of the American Association of Physical Anthropologists. In 2009, the meeting will be held in Chicago, Illinois, April 1-4.

DAA Subscription

The secretary-treasurer of the **Dental Anthropology Association** is Dr. Loren R. Lease of Youngstown State University.

Dr. Loren R. Lease
Department of Sociology and Anthropology
Youngstown State University
One University Plaza
Youngstown, Ohio 44555 USA

Telephone: (330) 941-1686
E-mail: lrlease@ysu.edu

Dental Anthropology now is published electronically and e-mailed to all members as a PDF. The PDF is published with color illustrations, though the printed version is still in black-and-white. If you **also** want to receive a hard copy, be sure to make this clear on the membership form at the DAA website or contact Loren.

Speed communication about your membership by contacting Loren directly (other officers may not have current membership lists).

Electronic versions (as PDF files) of the back issues of *Dental Anthropology* are available *gratis* at the Association's web site that is maintained at The Ohio State University: The web site's home page is:

http://anthropology.osu.edu/DAA/index.htm

NOTICE TO CONTRIBUTORS

Dental Anthropology publishes research articles, book reviews, announcements and notes and comments relevant to the membership of the *Dental Anthropology Association*. Editorials, opinion articles, and research questions are invited for the purpose of stimulating discussion and the transfer of information. Address correspondence to the Editor, Dr. Edward F. Harris, Department of Orthodontics, University of Tennessee, Memphis, TN 38163 USA (E-mail: eharris@utmem.edu).

Research Articles. The manuscript should be in a uniform style (one font style, with the same 10- to 12-point font size throughout) and should consist of seven sections in this order:

Title page	Tables
Abstract	Figure Legends
Text	Figures
Literature Cited	

The manuscript should be double-spaced on one side of 8.5 x 11″ paper (or the approximate local equivalent) with adequate margins. All pages should be numbered consecutively, beginning with the title page. Submit three (3) copies—the original and two copies—to the Editor at the address above (or see Electronic Submission, below). Be certain to include the full address of the corresponding author, including an E-mail address. All research articles are peer reviewed; the author may be asked to revise the paper to the satisfaction of the reviewers and the Editor. All communications appear in English.

Title Page. This page contains (a) title of the paper, (b) authors' names as they are to appear in publication, (c) full institutional affiliation of each author, (d) number of manuscript pages (including text, references, tables, and figures), and (3) an abbreviated title for the header. Be certain to include a working E-mail address and/or telephone number.

Abstract. The abstract does not contain subheadings, but should include succinct comments relating to these five areas: introduction, materials, methods, principal results, and conclusion. The abstract should not exceed 200 words. Use full sentences. The abstract has to stand alone without reference to the paper; avoid citations to the literature in the abstract.

Figures. One set of the original figures must be provided (or e-mailed) with the manuscript in publication-ready format. Drawings and graphics should be of high quality in black-and-white with strong contrast. Graphics on heavy-bodied paper or mounted on cardboard are encouraged; label each on the back with the author's name, figure number, and orientation. Generally it is preferable to also send graphs and figures as computer files that can be printed at high resolution (300 dpi or higher). Most common file formats (Windows or Macintosh) are acceptable; check with the Editor if there is a question. The hard-copy journal does not support color illustrations, but the PDF version does. Print each table on a separate page. Each table consists of (a) a table legend (at top) explaining as briefly as possible the contents of the table, (b) the table proper, and (c) any footnotes (at the bottom) needed to clarify contents of the table. Whenever possible, provide the disk-version of each table as a tab-delimited document; do not use the "make table" feature available with most word-processing programs. Use as few horizontal lines as possible and do *not* use vertical lines in a table.

Literature Cited. *Dental Anthropology* adheres strictly to the current citation format of the *American Journal of Physical Anthropology*. Refer to a current issue of the *AJPA* or to that association's web-site since the "current" style is periodically updated. As of this writing, the most recent guidelines have been published in the January, 2002, issue of the *AJPA* (2002;117:97-101). *Dental Anthropology* adheres to the in-text citation style used by the *AJPA* consisting of the author's last name followed by the year of publication. References are enclosed in parentheses, separated by a semicolon, and there is a comma before the date. Examples are (Black, 2000; Black and White, 2001; White *et al*., 2002). The list of authors is truncated and the Latin abbreviation "*et al*." is substituted when there are three or more authors (Brown *et al*., 2000). However, *all* authors of a reference are listed in the Literature Cited section at the end of the manuscript.

Electronic Submission. Electronic submission *instead of* sending hard copies of articles is strongly encouraged. For articles that undergo peer review, the editor will request submission of the final revision of a manuscript in electronic format, not interim versions. Files can be submitted on a 3.5″ diskette, or a 100-megabyte Iomega Zip disk or a compact disk (CD), either in Windows or Macintosh format. **Files can also be sent as E-mail attachments**. Microsoft Word documents are preferred, but most common formats are suitable. Submit text and each table and figure as a separate file. Illustrations should be sent in PDF or EPS format, or check with the Editor before submitting other file types. Be certain to label any disk with your name, file format, and file names.

Dental Anthropology

Volume 21, Number 2-3, 2008

Original Articles

Dental Anthropology Association

Published at
Craniofacial Biology Laboratory, Department of Orthodontics
College of Dentistry, The Health Science Center
University of Tennessee, Memphis, TN 38163 U.S.A.