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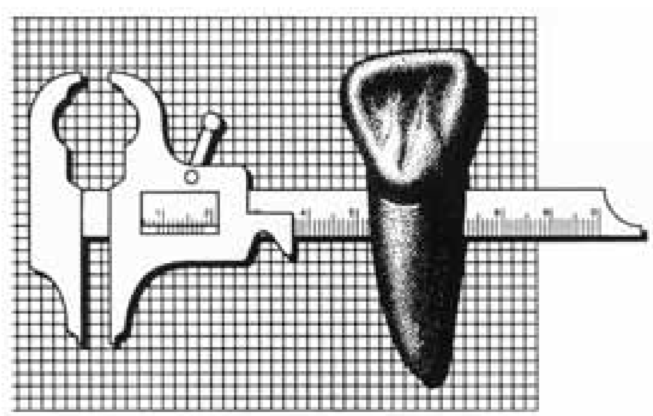

Craniofacial Biology Laboratory, Department of Orthodontics
College of Dentistry, The Health Sciences Center
University of Tennessee, Memphis, TN 38163 U.S.A.

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Address for Manuscripts

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

Address for Book Reviews

Dr. Debbie Guatelli-Steinberg
Department of Anthropology, Ohio State University
Newark, OH 43055 U.S.A.
guatelli-steine.1@osu.edu

Published at

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

The Effects of Sexual Dimorphism, Asymmetry, and Inter-trait Association on the Distribution of Thirteen Deciduous Dental Nonmetric Traits in a Sample of Pima Amerindians

Matthew W. Tocheri
Department of Anthropology, Arizona State University, Tempe AZ 85287-2402

ABSTRACT One hundred dental casts of modern Pima Amerindian children, 50 male and 50 female, were examined for the presence and expression of thirteen deciduous nonmetric traits. The effects of sexual dimorphism, asymmetry, and inter-trait association on trait presence were examined to evaluate their utility in population distance studies. No statistically significant differences between the sexes were observed. The majority of examined variants displayed a strong trend toward bilateral expression and no statistically significant differences between antimeres occurred. These data support the hypothesis that strong genetic components coupled with negligible environmental influences are involved in deciduous trait presence. Five statistically significant associations between variants were detected. Four of these involved a combination of incisor and canine shoveling within and between jaws. This indicates that their combined use in biological distance studies violates the mathematical assumption of independence. The lack of significant sexual dimorphism and asymmetry in the deciduous discrete traits examined herein supports their use in population distance analyses if precautions are taken to use non-associated traits.

The number of studies dealing with nonmetric variation in human deciduous teeth pale in comparison with those of the permanent dentition (Scott and Turner, 1997). This discrepancy has been attributed to the paucity of deciduous dental remains at archaeological sites (Kitagawa, 2000; Sciulli, 1998), their shorter functional life span in comparison with permanent teeth (Kitagawa, 2000), and the difficulty in obtaining a set of Hanihara's (1961) reference plaques (Mayhall, 1992). Several studies, however, indicate that deciduous nonmetric dental traits are useful tools in assessing the biological relationships of human populations (Goldstein, 1948; Grine, 1986, 1990; Hanihara, 1956, 1961, 1963, 1965, 1970; Hrdlicka, 1920; Johnse, 1947; Jorgensen, 1956; Lukacs and Walimbe, 1984; Sciulli, 1977, 1990, 1998; Smith, 1976, 1978).

A number of fundamental assumptions underpin the use of discrete dental traits in population analyses. These include the following:

1. genes strongly control trait presence and expression
2. environmental influences on trait presence and expression are negligible
3. the effects of sexual dimorphism on trait presence and expression are minimal
4. antimere asymmetry is the result of environmental rather than genetic influences
5. associations between traits are not biologically meaningful

Editor's note: Mr. Tocheri's paper was awarded First Prize for 2001 in the Albert A. Dahlberg student research competition sponsored by the Dental Anthropology Association.

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This paper tests the validity of the latter three assumptions as they relate to deciduous dental morphology. In turn, this sheds light on the first two assumptions. Establishing the utility of deciduous nonmetric traits in human population research is imperative if they are to be used successfully in biological distance analyses. While skeletal samples typically do not consist of a preponderance of juveniles, this is not always the case (Fairgrieve and Molto, 2000; Tocheri and Molto, in press). Therefore, deciduous nonmetric dental traits offer a valuable alternative source of biological data.

In this study, my first objective is to examine the effects of sexual dimorphism on deciduous trait presence and expression. Discrete dental traits rarely exhibit sexual dimorphism in the permanent teeth and when they do, it is primarily restricted to a few variants (Harris, 1980; Nichol, 1990; Scott, 1977; Turner et al., 1991). Theoretically, deciduous traits may be influenced by sex more than permanent traits since all deciduous teeth begin to form *in utero*. The presence of dihydrotestosterone and other androgens in male embryos act to differentiate them from females beginning around the seventh fetal week (Daly and Wilson, 1983; Mange and Mange, 1990). Dempsey et al. (1999) studied the permanent teeth of a large sample of twins and singletons (n = 448) and found that females which had a male twin "have consistently larger teeth (on average) than other females" (Dempsey et al., 1999: 577). They proposed that these differences were the result of "diffusion of sex hormones from male to female co-twins *in utero*" (Dempsey et al., 1999:577). How these naturally occurring steroids affect the development and expression of primary nonmetric variants is not well understood because few studies have examined sexual dimorphism in these traits. Hanihara (1965, 1970) reported that "no differences between sexes has been found" for several deciduous variants; however, he did not discuss any statistical methodology (Hanihara, 1965: 136, 1970). Grine (1990) examined a sample of Kalahari San children and found a lack of statistically significant sexual dimorphism in the deciduous traits he scored. Similarly, he found no sex differences in a sample of South African black children (Grine, 1986). Sex differences, however, may vary between populations in both dental (Harris, 1980) and skeletal traits (Ossenberg, 1976; Molto, 1985). Therefore, it is important to document the effects of sex on deciduous trait presence and expression in other human groups.

My second objective is to examine asymmetry in trait presence and expression on the anitmeres. Asymmetrical studies can reveal information pertaining to the environmental and functional influences on the presence of dental and skeletal discrete traits along with their underlying genotype (Mayhall and Saunders, 1986; Turner, 1985; Trinkaus, 1978). Several researchers have examined asymmetry in permanent (Bailey-Schmidt, 1995; Baume and Crawford, 1980; Biggerstaff, 1972; Harris, 1977; Meredith and Hixon, 1954; Nichol, 1990) and in primary dental traits (Townsend, 1981; Townsend and Brown, 1980, 1981) and have found it to be a random phenomenon influenced by the environment. A sample size greater than 100 is typically considered appropriate for statistical analyses of asymmetry (Garn et al., 1979; Smith et al., 1982), however, the documentation of observed trends in smaller samples can aid future research.

Understanding the associations among deciduous dental traits is necessary to increase their effectiveness in biological distance calculations. Associations between cranial nonmetric variables have been shown to adversely affect the calculation of C.A.B. Smith's Mean Measure of Divergence (MMD) (Molto, 1985). Similar results have been reported for distance analyses using permanent discrete traits (Hawkey, personal communication 2000; Nichol, 1990). Therefore, my final objective is to statistically examine the associations between these thirteen traits and critically evaluate their combined use in population distance studies.

MATERIALS AND METHODS

The sample consisted of 100 deciduous dental casts, 50 male and 50 female, of Pima Amerindians from southern Arizona. All casts were collected from living children by Albert A. and Thelma Dahlberg between 1949 and 1975 and are curated at the Dental Anthropology Laboratory at Arizona State University. The age and sex of each individual was recorded at the time of casting. The majority of casts examined in this study represent individuals between 5 and 10 years of age. Approximately 60% of their deciduous teeth were present for analysis.

Thirteen nonmetric traits were scored following the plaques (D series) and written descriptions of Hanihara (1961). Only teeth unaffected by wear or pathology were scored. A list of the examined traits and a description of how grades were dichotomized into present-absent categories is presented in Table 1. Hanihara's (1961) dichotomizing criteria were used for all traits. Throughout the text and tables the following abbreviations are used: l, lower; u, upper; i, incisor; c, canine; m, molar; 1, first in tooth series; 2, second in tooth series.

Twenty dentitions were randomly selected and re-scored on separate occasions. In order to analyze intra-observer reliability, an integral part of any discrete trait study (Molto, 1979; Nichol and Turner, 1986). Intra-observer reliability scores are reported by grade, presence/absence per tooth and presence/absence per individual in Table 2. Scoring consistency was lowest by grade (75%) and highest per individual (92%). I considered the observed scoring consistency by grade to be too low to analyze differences between degrees of expression. Therefore, only differences between trait presence and absence are reported herein. Per individual, seven out of 13 traits were scored reliably 100% of the time, two between 90-95%, and three between 80-85%. The Protostylid (lm2) was the least reliably scored trait (65% per individual).

The relative frequencies of each trait were calculated using the individual-count method. This assumes each trait is symmetrical and predominantly controlled by a single genotype; therefore, the strongest expression of the trait in an individual represents that genotype most accurately (Scott, 1980; Turner and Scott, 1977; Turner, 1985; Turner et al., 1991).

Differences in trait relative frequency between males and females and also between the right and left sides were analyzed. The Pearson chi-square test statistic was used to detect significance ($p < 0.05$). Inter-trait associations were measured using the phi coefficient with p values less than 0.01 considered significant following the recommendations of Molto (1985) and Sjøvold (1973). In all statistical analyses, if one or more cells had an expected count less than 5, Fisher's exact test was used to examine significance.

Asymmetry was investigated using the index of bilaterality (BI), calculated by dividing the frequency of bilateral presence by the sum of the frequencies of unilateral and bilateral presence, and multiplying by 100 (Molto, 1983). This index reveals the symmetrical

TABLE 1. The trait list and scoring procedure used in this study

Tooth	Trait	Grades Scored	Presence[1]
ui1	Shovel	0, 1, 2, 3	2, 3
ui2	Shovel	0, 1, 2, 3	2, 3
uc	Shovel	0, 1, 2, 3	2, 3
um1	Crown Pattern	2, 3H1, 3H2, 3M1, 3M2, 4-, 4	4-, 4
um2	Crown Pattern	3+A, 3+B, 4-, 4	4-, 4
um2	Carabelli's Cusp	0, 1, 2, 3, 4, 5, 6, 7	4 - 7
li1	Shovel	0, 1, 2, 3	2, 3
li2	Shovel	0, 1, 2, 3	2, 3
lc	Shovel	0, 1, 2, 3	2, 3
lm2	Protostylid	0, 1, 2, 3, 4, 5, 6	2 - 6
lm2	Cusp 7	0, 1, 2, 3	1 - 3
lm2	Central Ridge	0, 1	1
lm2	Distal Trigonid Crest	0, 1, 2	1, 2

[1]follows Hanihara's (1961) dichotomy

tendencies of a trait when it is present. In other words, individuals who exhibit bilateral absence of a trait are not included in the calculation of the index. An index value greater than 50 indicates the trait occurs more often bilaterally whereas a value less than 50 indicates it occurs more often unilaterally.

RESULTS

The relative frequencies of each trait by sex and by antimere are shown in Tables 3 and 4, respectively. No statistically significant difference between the sexes or between antimeres was observed ($p < 0.05$). All traits displayed a tendency toward bilateral expression (BI > 50) except for Crown Pattern (um1; BI = 0), Carabelli's cusp (um2; BI = 40) and Distal Trigonid Crest (lm2; BI = 50) as shown in Table 5.

Five statistically significant ($p < 0.01$) associations between traits occurred (Table 6). The significant association between Shoveling (ui1) and Crown Pattern (um2) is not likely to be biologically meaningful given that they develop in different developmental fields (Dahlberg, 1949). The remaining four associations, however, all involved combinations of incisor and canine shoveling within and between jaws. These significant associations strongly suggest a shared developmental pathway and strong genetic component for shoveling in the anterior teeth.

DISCUSSION

My first objective was to analyze the effects of sex on trait relative frequency. Of the 13 nonmetric traits examined in this study, none displayed statistically significant sexual dimorphism. This complements the results of Alvrus (2000) who found a "fairly low degree of sexual dimorphism" in deciduous metric traits in Pima children (Alvrus, 2000:12). Together, the results of these two studies suggest that, among the Pima, sex does not strongly affect the expression of metric or nonmetric deciduous traits. Grine (1986, 1990) also found a lack of statistically significant sex differences for Kalahari San and South African black children. Clearly, sexual dimorphism plays little role in the development of the examined deciduous crown traits within these population samples.

My second objective was to analyze trait asymmetry. None of the deciduous variants examined were expressed significantly more often on a particular side. Only one difference between antimeres approached statistical significance (Crown Pattern [um1], $p = 0.054$), and this is likely attributable to the overall low relative frequency of this trait (4.3%). Ten traits were expressed more often bilaterally (BI $\geq$ 60). The overwhelming tendency toward bilateral expression is consistent with the hypothesis that strong genetic components are involved in dental trait expression (Turner et al., 1991). Crown pattern (um1) and Carabelli's cusp (um2) were expressed more often unilaterally (BI $\leq$ 40) while Distal Trigonid Crest occurred bilaterally and unilaterally equally as often (lm2; BI = 50). The unilateral tendency of Crown pattern (um1) and Carabelli's cusp (um2) may be the result of their low relative frequency in the study sample ($\leq$ 5.1%). In sum, these data are consistent with the hypothesis that asymmetry is a random phenomenon representing environmental influences on the underlying genotype (Mayhall and Saunders, 1986; Nichol, 1990; Turner, 1985).

A fundamental assumption underlying the use of the MMD statistic is that the variables examined are not associated with one another (Sjøvold, 1973). Therefore, combining dental or skeletal nonmetric traits that are significantly associated violates the assumption of independence (Molto, 1985; Nichol, 1990). In this study, four statistically significant associations were detected

TABLE 2. Intra-observer reliability scores for this study

			Per Tooth				Per Individual	
Tooth	Side	Trait	Grade[1]	%	P/A[2]	%	P/A[3]	%
ui1	R	Shovel	15	75	19	95	20	100
	L		17	85	20	100		
ui2	R	Shovel	15	75	15	75	20	100
	L		19	95	20	100		
uc	R	Shovel	15	75	17	85	17	85
	L		16	80	17	85		
um1	R	Crown Pattern	17	85	20	100	20	100
	L		11	55	14	70		
um2	R	Crown Pattern	18	90	20	100	20	100
	L		17	85	20	100		
um2	R	Carabelli's Cusp	10	50	19	95	20	100
	L		12	60	20	100		
li1	R	Shovel	19	95	18	90	18	90
	L		18	90	18	90		
li2	R	Shovel	17	85	20	100	20	100
	L		15	75	20	100		
lc	R	Shovel	18	90	19	95	19	95
	L		16	80	19	95		
lm2	R	Protostylid	5	25	10	50	13	65
	L		8	40	13	65		
lm2	R	Cusp 7	11	55	15	75	17	85
	L		15	75	16	80		
lm2	R	Central Ridge	14	70	14	70	16	80
	L		15	75	14	70		
lm2	R	Distal Trigonid Crest	17	85	19	95	20	100
	L		18	90	19	95		
		Total	388	75	455	88	240	92

[1]identical grade was consistently scored per tooth examined (out of 20)
[2]presence/absence was consistently scored per tooth examined (out of 20)
[3]presence/absence was consistently scored per individual examined (out of 20)

that likely have biological meaning. All involved a combination of incisor and canine shoveling. This trait was associated between ui1-ui2, ui2-uc, ui2-lc, and uc-lc. Sciulli (1998) noted:

> For the total sample and in the Woodland and Pearson samples, shoveling shows strong associations between anterior teeth. The maxillary incisors are significantly associated with each other but independent of the canines, while the mandibular incisors are associated with each other, the maxillary incisors, and the mandibular canine. Shoveling of the maxillary canine is the only feature independent of shoveling in all other anterior teeth [Sciulli, 1998:196].

Clearly, shoveling in the anterior teeth is likely the result of a similar, if not identical genetic component. If this is true, the combined use of shoveling traits on different teeth in biological distance studies may adversely affect the results of the MMD statistic. Molto (1985) demonstrated that using six associated cranial variants ($p < 0.015$) in a battery of 27 significantly altered the MMD results. Nichol (1990) and Hawkey (personal communication, 2000) have found similar results using significantly associated permanent discrete traits. Molto (1985) aptly summarized:

> In closing, I would like to emphasize that the concept of distance is a theoretical mathematical concept that has been borrowed and applied to population biology. Debate continues as to the meaning and/or legitimacy of distances computed using biological data (Sjøvold, 1977). In view of this, the very least researchers can do, is to obey the assumptions outlined by mathematical theory. This means that biological distances should be computed using variates that, except for an acceptable number of chance associations, are statistically independent of each other [Molto, 1985:64].

TABLE 3. Relative frequencies of 13 deciduous dental traits and their distribution by sex in a Pima Amerindian sample[1-2]

		Total		Males		Females		
Tooth	Trait	N	%	N	%	N	%	P
ui1	Shovel	53	50.9	27	51.9	26	50.0	0.893
ui2	Shovel	73	71.2	39	69.2	34	73.5	0.686
uc	Shovel	99	42.4	49	36.7	50	48.0	0.257
um1	Crown Pattern	94	4.3	46	4.3	48	4.2	1.000
um2	Crown Pattern	97	88.7	48	87.5	49	89.8	0.721
um2	Carabelli's Cusp	99	5.1	50	2.0	49	8.2	0.204
li1	Shovel	20	5.0	14	7.1	6	0.0	1.000
li2	Shovel	43	16.3	25	16.0	18	16.7	1.000
lc	Shovel	95	74.7	47	76.6	48	72.9	0.680
lm2	Protostylid	99	80.8	49	83.7	50	78.0	0.474
lm2	Cusp 7	96	70.8	49	77.6	47	63.8	0.139
lm2	Central Ridge	94	70.2	47	72.3	47	68.1	0.652
lm2	Distal Trigonid Crest	97	28.9	48	35.4	49	22.4	0.159

[1]N, # of individuals; %, relative frequency.
[2]P, significance level (Chi-square or Fisher's exact test).

Therefore, researchers should be extremely cautious when using a number of deciduous shoveling traits in biological distance analyses. The use of "key" teeth for deciduous variants, as is common practice in permanent discrete trait studies (Hawkey, 1998), is recommended.

CONCLUSIONS

The nonmetric traits of the deciduous dentition examined herein showed no statistically significant sex or side differences in trait relative frequency. The majority of the traits were expressed bilaterally. Together these data suggest the deciduous traits examined are primarily under genetic control with negligible environmental influences involved in their expression. Four statistically significant associations between shoveling traits on the anterior teeth were interpreted as representing a shared developmental pathway and genetic component. Therefore, using more than one deciduous shoveling trait as part of a trait battery measuring biological distance would violate the mathematical assumption of independence between variables. In sum, the observed lack of significant sexual dimorphism and asymmetry in this study supports the use of deciduous discrete traits

TABLE 4. Relative frequencies of 13 deciduous dental traits and their distribution by antimere in a Pima Amerindian sample[1-2]

		Total		Right		Left		
Tooth	Trait	N	%	2N	%	2N	%	P
ui1	Shovel	53	50.9	53	50.9	50	44.0	0.481
ui2	Shovel	73	71.2	66	68.2	71	70.4	0.776
uc	Shovel	99	42.4	94	36.2	97	40.2	0.566
um1	Crown Pattern	94	4.3	86	4.7	91	0.0	0.054
um2	Crown Pattern	97	88.7	94	83.0	95	88.4	0.285
um2	Carabelli's Cusp	99	5.1	99	3.0	96	4.2	0.718
li1	Shovel	20	5.0	18	5.6	18	5.6	1.000
li2	Shovel	43	16.3	38	13.2	39	12.8	1.000
lc	Shovel	95	74.7	89	73.0	93	66.7	0.350
lm2	Protostylid	99	80.8	96	74.0	98	74.5	0.933
lm2	Cusp 7	96	70.8	91	65.9	94	61.7	0.549
lm2	Central Ridge	94	70.2	89	62.9	91	64.8	0.789
lm2	Distal Trigonid Crest	97	28.9	94	19.1	94	24.5	0.377

[1]2N, # of sides; %, relative frequency.
[2]P, significance level (Chi-square or Fisher's exact test).

TABLE 5. The symmetrical tendencies of 13 deciduous dental traits used in this study

Tooth	Trait	Trait Presence Bilateral	Unilateral	Index of Bilaterality	Symmetrical Tendency
ui1	Shovel	22	3	88.0	bilateral
ui2	Shovel	43	4	91.5	bilateral
uc	Shovel	31	7	81.6	bilateral
um1	Crown Pattern	0	2	0.0	unilateral
um2	Crown Pattern	76	6	92.7	bilateral
	Carabelli's Cusp	2	3	40.0	unilateral
li1	Shovel	1	0	100.0	bilateral
li2	Shovel	3	2	60.0	bilateral
lc	Shovel	56	8	87.5	bilateral
lm2	Protostylid	64	12	84.2	bilateral
	Cusp 7	50	14	78.1	bilateral
	Central Ridge	49	10	83.1	bilateral
	Distal Trigonid Crest	13	13	50.0	---

in population analyses if the necessary precautions are taken involving significant associations between variants.

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TABLE 6. Associations between the 13 deciduous dental traits used in this study[1-3]

Tooth	Tooth Trait	ui1 SH	ui2 SH	uc SH	um1 CP	um2 CP	um2 CC	li1 SH	li2 SH	lc SH	lm2 PR	lm2 C7	lm2 CR	lm2 DTC
ui1	SH	-	**0.36**	0.17	-0.21	**0.39**	0.00	-	-0.05	0.04	0.16	0.19	0.31	-0.06
ui2	SH	**0.01**	-	**0.41**	0.16	0.31	0.02	-	0.14	**0.42**	-0.04	0.28	0.03	-0.10
uc	SH	0.21	**0.00**	-	-0.07	0.04	0.17	0.25	0.26	**0.28**	-0.05	0.08	0.13	-0.09
um1	CP	0.23	0.31	0.64	-	0.08	-0.05	-	0.20	0.13	-0.02	-0.15	-0.02	0.03
um2	CP	**0.01**	0.02	0.76	1.00	-	0.08	0.12	0.19	0.24	-0.09	-0.09	0.05	-0.13
um2	CC	1.00	1.00	0.16	1.00	1.00	-	-	-0.10	-0.09	-0.12	-0.06	0.16	-0.15
li1	SH	-	-	0.45	-	1.00	-	-	1.00	-0.40	0.13	0.10	-0.39	-0.14
li2	SH	1.00	0.64	0.11	0.32	0.57	1.00	0.05	-	0.09	-0.04	0.12	-0.14	0.00
lc	SH	0.79	**0.00**	**0.01**	0.57	0.03	0.59	0.25	1.00	-	0.13	-0.03	-0.06	0.11
lm2	PR	0.29	1.00	0.66	1.00	0.68	0.25	1.00	1.00	0.24	-	0.16	-0.03	-0.03
lm2	C7	0.18	0.02	0.42	0.21	0.50	0.62	1.00	0.65	0.78	0.12	-	0.23	0.05
lm2	CR	0.02	0.81	0.21	1.00	0.73	0.32	0.26	0.39	0.61	0.81	0.02	-	0.05
lm2	DTC	0.68	0.42	0.37	1.00	0.29	0.32	1.00	1.00	0.29	0.80	0.63	0.60	-

[1]SH, shovel; CP, crown pattern; CC, Carabelli's cusp; PR, protostylid; C7, cusp 7; CR, central ridge; DTC, distal trigonid crest.
[2]phi coefficients are above the main diagonal; p values are below the main diagonal.
[3]**bolded values** are statistically significant at the 0.01 level.

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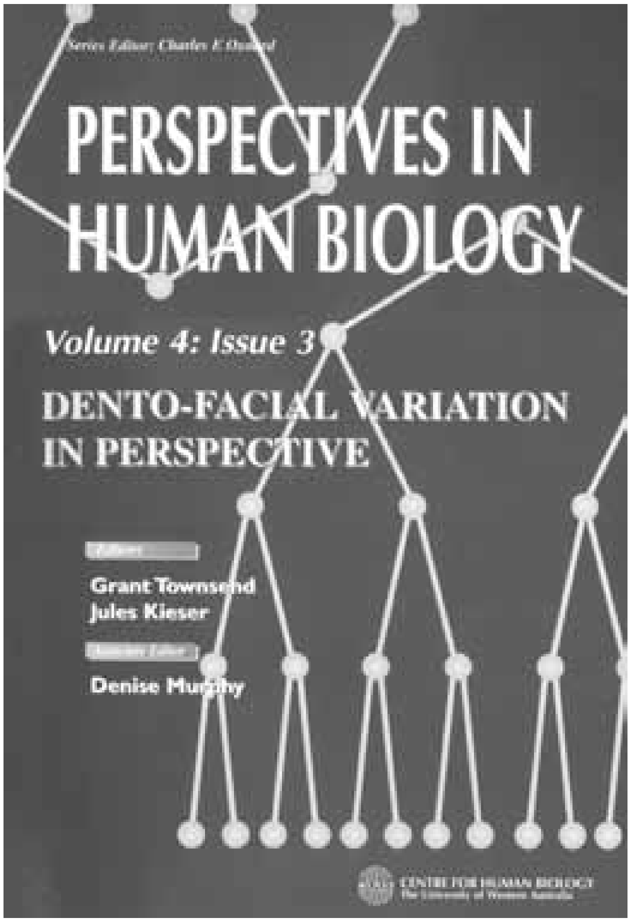
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DENTO-FACIAL VARIATION
IN PERSPECTIVE
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Jules Kieser
Denise Murphy

Dental Paleopathology of the Ray Site (12W6), Indiana

Tammy R. Greene
Department of Anthropology, University of Alaska, Fairbanks AK 99775

ABSTRACT The Ray site (1 2W6), in southern Indiana, contains several secondary burials, two of which have been dated to the Mississippian period (A.D. 1050-A.D. 1450). Three burial styles were noted: (1) burials lined with stone slabs and containing Mississippian pottery, (2) burials lined with stone slabs without Mississippian pottery, and (3) burials not lined with stone slabs and without Mississippian pottery. The purpose of this study was to determine the biological homogeneity of this poorly preserved skeletal assemblage via an analysis of dental pathological conditions, the frequency and expression of which are known to associate with distinct dietary and/or settlement patterns. Conditions studied include the frequency of hypoplastic defects and carious lesions, the type of hypoplastic defects, the earliest age of onset of hypoplastic defects, and the location of carious lesions. A total of 437 teeth were scored for hypoplastic defects and 433 were scored for carious lesions. No significant difference in dental pathologies was found between burial styles. Therefore, despite considerable burial heterogeneity, dental pathological conditions suggest that individuals from all burials consumed an equally cariogenic diet and underwent similar childhood stresses. It is most likely that all burials are from the same temporal and social group and that the different burial styles represent different stages in the processing of the remains of individuals from a high social status Mississippian mortuary.

Many researchers have determined that the expression of certain dental pathological conditions is not randomly distributed through time among prehistoric humans from the American Midwest (e.g., Goodman et al., 1984b; Sciulli and Schneider, 1986; Larsen et al., 1991; Schmidt, 1998; Schmidt and Williamson, 1998). Rather, these conditions tend to correlate with a population's diet, density, and degree of sedentism. Populations that consumed domesticates such as maize and lived in dense settlements tended to suffer more profoundly from dental caries and disruptions in tooth formation than those who consumed fewer or no domesticates and lived in small groups (Powell, 1985). Researchers have verified associations between diet and dental disease throughout the world (e.g., Enwonwu, 1981; Walker and Erlandson, 1986; Kelly et al., 1991; Buikstra, 1992).

Archeology textbooks that discuss the transition to agriculture tend to ignore the biological record in favor of the more easily defined and recognized social, cultural, and technological transformations (Larsen, 1995). However, biological changes are an essential concomitant of lifeway transitions. These biological changes reflect non-specific indicators of diet, health, and workload, and sometimes, more specific indicators such as particular diseases or individual activities. Segments of a single population may be affected differentially by adopting agriculture. Likewise, populations may experience idiosyncratic biological changes, depending upon their region, the agricultural resource being adopted, and preceding subsistence strategies. In other words, alterations that accompanied agriculture may have been highly localized (Larsen, 1995).

Recent preliminary studies of the Ray site, which has been considered by archeologists to be a single-component cemetery, have shown several contradictions to the general rules of small Mississippian mortuary sites. Differences in the orientation of the graves, positioning of the remains, and inclusion of artifacts may suggest heterogeneity that exceeds typical small Mississippian cemeteries. The purpose of this study was to determine whether the skeletal sample is also biologically heterogeneous. Since the frequency and expression of dental pathological conditions are known to associate with distinct dietary or settlement patterns, heterogeneity of these conditions within the assemblage would suggest that most heterogeneity is due to representation of more than one population or temporal period. For example primary and secondary interments, which represent different stages in the processing of remains may be seen at many high social status Mississippian mortuaries, and could be represented by different burial styles. Hypoplastic enamel defects and carious lesions are analyzed to determine whether these conditions vary systematically by grave style or the inclusion of artifacts, thus exposing culturally and/or temporally distinct subgroups.

Hypoplasia

Hypoplastic enamel defects include various malformations on the crown surface from furrows to pits that represent episodic disruption of enamel matrix secretion during growth (Goodman and Armelagos, 1985; Goodman and Rose, 1991). The surface profile of the tooth is altered due to a convergence of the striae of

Editor's note: Ms. Greene's paper was awarded Honorable Mention for 2001 in the Albert A. Dahlberg student research competition sponsored by the Dental Anthropology Association.

Retzius as they approach the enamel surface as well as abnormal prism structure along the defect. Because of the appositional nature of enamel, the area of the defect is often overlapped by normal enamel, resulting in locally thin but not necessarily absent enamel (Pindborg, 1970; Goodman and Rose, 1990).

Many childhood stressors have been linked to hypoplastic enamel defect formation, including vitamin A and D deficiencies, fever, gastroenteritis (Goodman et al, 1984a) under- and over-nutrition, and hormonal changes (Goodman and Armelagos, 1985). In fact, most stressors, if severe enough, result in disruptions of enamel development (Goodman and Rose, 1991), although it is likely that the combination of several stressors is necessary to form a defect. While it may be impossible to distinguish the exact cause of hypoplastic enamel defects, their presence or absence provides insight into the metabolic state of an individual at the time of their dental matrix formation (Goodman and Rose, 1990). Teeth that develop while host resistance is low and environmental insults are high are more likely to have hypoplastic defects (Goodman and Armelagos, 1985). The presence of a hypoplastic defect on the tooth suggests that the health of the child was sufficient to overcome those environmental insults.

Hypoplastic enamel defects are found in every Native American group and are more frequent in agricultural groups (Sciulli, 1978; Goodman and Rose, 1990). Sciulli (1978) presents frequencies of hypoplastic enamel defects for several groups from various time periods: a pre-agricultural group from Ohio showed a frequency of 33%; mixed economy groups showed an average of 28.5%; agricultural groups showed frequencies from 43% to 70%.

Age at which the hypoplastic defect occurs has also been shown to change through time. Goodman et al. (1984a) examined two successive prehistoric populations from Dickson Mounds (A.D. 950-1150, mixed economy; and A.D. 1150-1300, agriculture) in Illinois. The former group had a peak frequency between 3.0 and 3.5 years. The latter had a peak frequency between 2.5 and 3.0 years (Goodman et al., 1984a).

Carious Lesions

Carious lesions are among the most frequently reported pathological conditions of the dentition. The lesions are areas of the teeth that have been destroyed by acids produced in dental plaque by bacterial fermentation (Heloe and Haugejorden, 1981). Carious lesions develop under dental plaques, which are dense bacterial masses (Gibbons and Van Houte, 1975). Streptococci and gram-positive filamentous bacteria are most often associated carious lesions (Gibbons and Van Houte, 1975). The bacteria feed on the carbohydrates in the mouth producing waste in the form of lactic acid (Hillson, 1979).

The relationship between diet and carious lesions has been well-established (Jacobsen and Hansen, 1974; Pedersen, 1938; Mayhall, 1970; Bang and Kristoffersen, 1972). It is accepted that increased dependency on foods such as sugars and carbohydrates leads to a higher incidence of carious lesions. Increases in carious lesion rates accompanying a dietary shift to greater carbohydrate consumption have been noted in Greenland (Jacobsen and Hansen, 1974; Pedersen, 1938), Canada (Mayhall, 1970), Alaska (Bang and Kristoffersen, 1972), Africa (Enwonwu, 1981), Asia (Infirri and Barmes, 1979), and Europe (Corbett and Moore, 1976). The location of carious lesions along the tooth row has also been shown to change with subsistence strategies. Lesions tend to occur almost exclusively at the CEJ (cemento-enamel junction) in pre-agricultural populations. Foods commonly become lodged around the gum-line. Populations that regularly consume refined carbohydrates more often develop carious lesions on the crowns. Carbohydrates are sticky and are easily trapped in the grooves in the enamel surface (Smith, 1986).

Frequencies of carious lesions differ among males and females in many geographic locations (Lukacs, 1996). However, Mississippian sites in the Midwest do not tend to show differences between the sexes (Smith, 1986). Thus foods consumed by males and females are equally cariogenic. The relationship of carious lesion frequency with age is somewhat less established. The Angel site, located near and believed to be contemporaneous with the Ray site, shows a decrease in carious lesion frequency with age (Schmidt, 1998). This decrease may be related to tooth wear. As a tooth wears, there are fewer grooves in which sticky foods may become lodged, thereby reducing the risk of bacterial decay.

MATERIALS

The current study examined mortuary homogeneity in a small late prehistoric mortuary. The Ray site (1 2W6) overlooks Little Pigeon Creek near its entry into the Ohio River in Warrick County, Indiana. The Ray site is six miles east of the Angel site (l2Vgl) and one mile north of the Yankeetown site (12W1). Black (n.d.) first characterized the Ray site as Yankeetown (A.D. 750 - 1050). In a reevaluation, Ball (1993) suggests that the Ray site represents an early Angel phase (Mississippian period, A.D. 1050-1450) mortuary placed over an earlier Yankeetown domestic occupation site. Placement of the Ray site within the Angel phase and its relationship to the Angel site are not entirely clear (Ball, 1993).

The excavations produced eleven prehistoric burials and several intrusive Euro-American burials. The Euro-American burials were not examined. Three distinct burial classifications can be seen. These include (1) burials with Mississippian pottery and stone slabs, (2) burials with stone slabs without Mississippian pottery, and (3) burials with no Mississippian pottery

TABLE 1. Description of burials[1]

Burial	MNI	Stone Slab?	Mississippian Pottery?
1	Unknown	Shale	Sandstone pipe
2	Unknown	None	No
3	10	Shale, Horizontal?	Yes
4	17	None	No
5a	1	Shale, Vertical	No
5b	8	Sandstone, Vertical	No
6	1	None	No
7	2	None	Unknown
8	1	None	No
9	Unknown	None	No
10	6	None	No
11	1	Shale, Horizontal	No
12	5	Shale & Sandstone, Vertical	Yes
13	2	None	No

[1]MNI (minimum number of individuals) was determined through dental remains. The numbers given in the field notes were based on rough skull counts and therefore may differ from dental counts.

or stone slabs. There are no burials at the Ray site with Mississippian pottery that do not have stone slabs. The association of burials 7, 8, and 9 with any burial style is unclear (Ball, 1993), thus these burials are not considered in the present study. Burials 1 and 2 were not collected (Black, n.d.). See table 1 for a description of the burials.

METHODS

All Ray site teeth were first cleaned with a weak ethyl acetate solution to remove the white paint that had been placed on the crowns for labeling in the 1950s. Teeth still housed in bony sockets had been covered with the preservative Aluvar in the field before removal of the soil. Removing the preservative with the ethyl acetate caused minimal damage to the crowns; however, some required reconstruction. Teeth that appeared cracked under the preservative were not cleaned and were not included in the study. An inventory of all complete and fragmented teeth from the Ray site was taken in order to establish a minimum number of individuals (MNI). Because of the low occurrence of primary teeth in this sample, they cannot be studied separately and were therefore not examined. Table 2 summarizes the inventory of permanent teeth that were included in the study.

Only permanent teeth with fully formed crowns were scored for hypoplastic enamel defects. Permanent teeth that are not fully developed may not yield accurate results. If enamel was missing from the labial side of an anterior tooth or the buccal side of a molar, that tooth was not scored. In order to remain conservative and not score normal variation in perikymata as hypoplastic enamel defects, only those defects that could be seen with the naked eye were scored. All features that were suspected of being hypoplastic after initial examination with the naked eye were then confirmed with a 10X hand lens and fingernail palpation.

The LEH classification system as presented in Buikstra and Ubelaker (1994) was used to score the defects. However, due to small sample sizes, it was necessary to collapse the defects into two categories for statistical analysis, namely (a) grooves and (b) pits.

TABLE 2. Number of teeth available for scoring[1]

	Style 1	Style 2	Style 3	Total
Anterior teeth scored for hypoplastic defects	36	37	88	161
Posterior teeth scored for hypoplastic defects	82	35	159	276
Total scored for hypoplastic defects	118	72	247	437
Anterior teeth scored for carious lesions	35	35	89	159
Posterior teeth scored for carious lesions	83	35	156	274
Total scored for carious lesions	118	70	245	433

[1]Style 1 refers to those burials with stone slabs and Mississippian pottery. Style 2 refers to those burials with stone slabs but no Mississippian pottery. Style 3 refers to those burials with no stone slabs or Mississippian pottery.

Age is assigned based on the third of the crown on which the defect occurs. Lesions on the cervical-most third are most recent and those on the occlusal-most one-third are the earliest, with each third representing, in general, about 2 years (Schour and Massler, 1940; Massler et al., 1941). This system was used to place the defects into categories of 0-2 years, 2-4 years, 4-6 years, or 6 and over, depending on the developmental timing of the tooth.

All erupted permanent teeth were scored for the presence of carious lesions. Any tooth that was missing more than 1/4 of the crown due to fracture was not scored. Carious lesions were scored according to standards presented by Buikstra and Ubelaker (1994). Due to small sample sizes, lesion location was collapsed into occlusal (including occlusal and smooth surface lesions, including buccal pits and grooves) and cervical (including cervical and interproximal lesions) categories for statistical analysis. Because the majority of the teeth in this sample consist of the crown only, root caries were not scored for any tooth. Carious lesions were confirmed using a 1OX hand lens. Rudney et al. (1983) suggest that visual identification is more reliable than dental probe or radiographic techniques. As suggested by Moore and Corbett (1971), only those lesions that have penetrated the surface enamel were scored.

Non-carious pulp exposure (attrition) was also recorded. While attrition is not a pathological condition, it was recorded in order to control for time since eruption of the tooth. Wear on molars was scored according to methods presented by Scott (1979). Teeth receive a score of four, being unworn to polished, to 40, having no remaining enamel. For this study, the median wear score of 11 was used to divide the teeth into categories of high wear and low wear. Wear on incisors, canines, and premolars was scored according to methods presented by Smith (1984). Teeth receive a score of 1, being unworn to polished, to 8, having no remaining enamel. The median wear score of three was used to divide teeth into categories of high wear and low wear.

The burial style categories used here include those burials that have stone slabs and Mississippian pottery (Style 1), those burials that have stone slabs but no pottery (Style 2), and those burials that have no stone slabs or pottery or (Style 3). Small sample sizes did not permit comparisons between each tooth type. Therefore, tooth types were collapsed into anterior (incisors, canines and premolars) and posterior (molars) categories. The number of teeth is approximately equal in most categories at the Ray site (Table 2). However, those burials with stone slabs but no pottery have a significantly greater number of incisors and fewer premolars within the anterior tooth category than the other burial styles. This may potentially bias the number of hypoplastic defects among the anterior teeth of this burial style.

Analysis of variance (ANOVA) was used to test differences in the numbers of hypoplastic defects and age of occurrence as well as the numbers of carious lesions per tooth between each of the three burial styles. The test examines the effects of the independent variables on the expression of hypoplastic defects or carious lesions (Kimble, 1978). All ANOVAs were run on SYSTAT for Windows version 6.0.1. In addition, to the parametric ANOVAs, nonparametric chi-square tests were used to test the differences in the number of teeth with at least one LEH or carious lesion as well as the types of LEHs and location of carious lesions. The chi-square tests are goodness-of-fit tests with two degrees of freedom (Thomas, 1986).

RESULTS

A total of 437 teeth were scored for hypoplastic defects. The burials with stone slabs and Mississippian pottery present (Style 1) contained 118 teeth (31% of which have hypoplastic defects) while those with stone slabs but without Mississippian pottery (Style 2) contained 72 teeth (46% of which have hypoplastic defects). Those burials with no stone slabs or Mississippian pottery (Style 3) contained 247 teeth (25% of which have hypoplastic defects). There is an average of 0.85 defects per tooth in burial style 1, 1.03 defects per tooth in style 2 and 0.82 defects per tooth in style 3. The overwhelming majority of defects in all groups are horizontal linear grooves with very few pits. The earliest age of onset for all groups has a peak frequency between 2 and 4 years.

A goodness-of-fit test suggests that there are no significant difference in frequency of affected posterior teeth between the burial styles (Table 3). However, burial style 2 has a greater proportion of anterior teeth with at least one hypoplastic defect than the other burial styles. Goodness-of-fit tests show no significant difference in the type of hypoplastic defect on the

TABLE 3. Chi-square tests for presence of hypoplastic defects among burial styles[1]

	n	Chi-square
Anterior teeth only	161	6.74
Posterior teeth only	276	3.60

[1]None was statistically significant.

TABLE 4. Chi-square statistic for LEH type among burial styles

	n	Chi-square
Anterior teeth only	78	6.91*
Posterior teeth only	57	1.11

*P < 0.05

TABLE 5. Results of ANOVA for number of hypoplastic defects per tooth among burial styles[1]

Source	n	F	P
Anterior teeth only	161	1.25	0.29
Posterior teeth only	276	1.56	0.21

[1]None was significant statistically.

TABLE 6. Results of ANOVA for earliest age of occurrence for hypoplastic defects among burial styles[1]

Source	n	F	P
Anterior teeth only	75	1.79	0.17
Posterior teeth only	51	0.08	0.92

[1]None was significant statistically.

posterior teeth (Table 4). However, burial style 3 has a greater proportion of pits on the anterior teeth than the other burial styles. Significance for these tests and all other tests reported in this paper are based on an alpha of 0.05. ANOVA suggest no significant differences for the number of defects per tooth or earliest age at onset, regardless of tooth type. Table 5 summarizes the ANOVA results.

A total of 433 teeth were scored for carious lesions. Burial style 1 contains 118 teeth (29% of which have carious lesions). Burials style 2 contains 70 teeth (30% of which have carious lesions). Burial style 3 contains 245 teeth (28% of which have carious lesions). There is an average of 0.86 defects per tooth in burial style 1, 0.90 defects per tooth in burial style 2, and 0.85 defects per tooth in burial style 3. All groups have more occlusal than interproximal lesions.

Goodness-of-fit tests suggest that there are no significant difference between the burial styles regardless of tooth type or degree of wear (Tables 7 and 8). ANOVA suggests that no significant differences exist between the burial styles regardless of tooth type (Table 9).

DISCUSSION

Overall, hypoplastic defects are very similar among all burial styles represented at the Ray site. However, some differences were found. Burials with stone slabs but without Mississippian pottery (style 3) had a greater proportion of anterior teeth with hypoplastic defects than the other burial styles. However, those burials with stone slabs but without Mississippian pottery (style 2) had a substantially larger number of incisors and fewer premolars than the other burial styles. Because incisors are more likely to become hypoplastic, it is not surprising that the burial style with more incisors also has more defects.

The mean number of hypoplastic defects per tooth does not vary significantly with burial style. This finding suggests that individuals from one burial style did not undergo a greater number of stresses during the time of development than the other burial styles.

The earliest age at onset of hypoplastic defects does not vary significantly with burial style. Some may argue that given the broad age ranges used, this would reflect the tendency of hypoplastic defects to form on the middle thirds of the crowns (i.e., the age range 2-4 tends to fall the middle third for most teeth). However, the distribution for all age ranges was similar among the burial styles. All burial styles had a peak frequency in the 2-4 year category with the second highest occurrence in the 4-6 year category and the lowest occurrence in the 0-2 year category. This distributions suggest that within each age category, individuals from all burial styles were equally susceptible to hypoplastic defect formation.

The type of hypoplastic defect does vary significantly with burial style. Burial style 3 has a significantly greater number of pits on the anterior teeth than do the other burial styles. All pits from this burial style are found in a single burial. Therefore, the greater number of pits is only representative of one burial, not the burial style as a whole. The pits are also from a minimum of two individuals. Therefore, the sample may be biased by a few individuals. It has been suggested that different types of hypoplastic defects (grooves vs. pits) may have different etiologies in some populations (Lovell and Whyte, 1999). However, there is no evidence in the literature to substantiate this claim. Thus the nominal differences seen in hypoplastic defect frequency are most likely biased and to not suggest the presence of two populations at the Ray site.

Comparisons with other sites from known time

TABLE 7. Results of Chi-square tests for presence of carious lesions among burial styles[1]

	n	Chi-square
Anterior teeth only	159	1.04
Posterior teeth only	274	3.28
High wear only	185	0.55
Low wear only	248	1.00

[1]None was significant statistically.

TABLE 8. Chi-square tests for location of carious lesions among burial styles[1]

	n	Chi-square
Anterior teeth only	13	1.64
Posterior teeth only	115	4.39
High wear only	64	3.91
Low wear only	62	2.07

[1]None was significant statistically.

TABLE 9. Results of two-way ANOVA for number of carious lesions per tooth among burial styles[1]

Source	n	F	P
Anterior teeth only			
Burial Style	159	0.52	0.60
Wear	159	0.06	0.81
Style-x-Wear	159	1.55	0.21
Posterior teeth only			
Burial Style	274	2.09	0.13
Wear	274	0.26	0.61
Style-x-Wear	274	1.10	0.33

[1]None was significant statistically.

periods are difficult because most data are given per individual and most teeth from the Ray site mortuary could not be reassociated. Peak frequencies for age of onset provided for both the Late Woodland (3.0-3.5 years) and the Mississippian (2.5-3.0 years) groups at the Dickson Mounds (Goodman et al., 1984a) are given in half-year age ranges and both fall into the 2-4 year category used in this study.

The frequency and expression of carious lesions was very similar for each burial style. The proportion of teeth with at least one carious lesion does not vary significantly based on burial style, regardless of tooth type or degree of wear. The mean number of lesions per tooth does not vary significantly based on burial style, regardless of tooth type or degree of wear. This would suggest that there are no factors, either dietary (e.g., amount of carbohydrates consumed) or biological (e.g., differences in saliva flow or pH) that make the teeth of any one burial style more susceptible to caries. The location of carious lesions does not differ significantly based on burial style, regardless of tooth type or degree of wear. This would suggest that the diets of individuals from each burial style were equally cariogenic.

The frequency and expression of carious lesions at the Ray site are consistent with other known Mississippian period populations. The number of carious lesions per anterior tooth at the Ray site is nearly identical to that listed for the Kane Mounds, a Mississippian period site in Illinois (Milner, 1984). The number of lesions per posterior tooth is also very similar, the only difference occurring when the category is divided into specific tooth types. The second molars of Milner's (1984) sample appear to have a greater number of lesions per tooth than those from the Ray site, however this may be due to smaller sample sizes for this tooth at the Ray site. Thirty-six percent of the posterior teeth of the Kane Mounds groups have occlusal carious lesions. After correcting for Milner's (1984) scoring method, 33% of the posterior teeth from the Ray site have occlusal carious lesions.

It appears that all individuals from the Ray site mortuary were from the same temporal and social group. The high degree of processing of the remains, the commingled nature of the remains, and the elaborate nature of some of the graves (i.e., stone slabs) suggest that the Ray site mortuary contained individuals of higher social status (Goldstein, 1980). Because there are more stages in processing the higher-status burials, primary and secondary interments are usually present (Goldstein, 1980). It is likely that the different burial styles at the Ray site represent different stages in processing the remains of individuals from the same temporal/social group rather than distinct subgroups. Because there is no difference in frequency or expression of hypoplastic defects or carious lesions between the burial styles, and the carious lesion data for this site are not inconsistent with known Mississippian mortuaries, this study would suggest that all burial styles present at the Ray site are indeed associated with the Mississippian period.

SUMMARY AND CONCLUSIONS

The purpose of this study was to assess, via an analysis of dental pathological conditions, the biological homogeneity of a small Mississippian mortuary with differing burial styles. Despite burial heterogeneity, there is no evidence among the dental pathological conditions studied to suggest that more than one population is present in the Ray site mortuary. The frequency and expression of hypoplastic defects suggests individuals all burial styles underwent similar childhood stresses. The frequency and expression of carious lesions also suggest that individuals from all burials consumed an equally cariogenic diet. The different burial styles present at the Ray site most likely represent different stages in the processing of remains consistent with high social status Mississippian mortuaries. Future studies should attempt to compare the dental pathological conditions at the Ray site with those of other small Mississippian high and low status mortuaries in the Midwest.

ACKNOWLEDGEMENTS

The Ray site skeletal material is on loan to the University of Indianapolis, Archeology and Forensics Laboratory from the Indiana University, Glenn Black Laboratory. I would like to thank Stephen Ball of the Glenn Black Laboratory and Christopher Schmidt of the University of Indianapolis for access to the skeletal material.

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Tubercle of Carabelli: A Review

André Correia and Carla Pina
Faculty of Dental Medicine, University of Porto.
Rua Dr. Manuel Pereira da Silva, 4200 Porto, Portugal

ABSTRACT The tubercle of Carabelli is an important morphological characteristic in the studies of dental morphology and forensic medicine. This trait has been used as an anthropological measure. The purpose of this work is to make a review of the information available about this dental characteristic. Its morphology, genetic characteristics and frequency are discussed in this article.

The great number of works published with emphasis on this dental trait reflects its importance in dental morphology. The tubercle of Carabelli is to dental morphology what the ABO blood group system is to serology (Scott and Turner, 2000).

This morphological trait was first described in 1841, by Georg Carabelli Edlen von Lunkaszprie (Johnson, 1999). However, other authors indicate that 1842 was the date for the first reference of this dental structure (Kraus, 1959; Bang, 1972; Mizoguchi, 1993; Woelfel, 1997). Georg Carabelli (1787-1842), was an Hungarian *syphilologist* (syphilis then being rampant in Hungary and elsewhere) and dermatologist (Hoffman, 1968; Della Serra, 1976). Carabelli also was a professor of dental surgery in the Petrograd Academy (Mizoguchi, 1993) and was court dentist to the Austrian Emperor Franz (Johnson, 1999).

Other monographs on syphilis, for example Sabourad (1917), likewise claim that this dental characteristic is a pathognomonic sign of hereditary syphilis (Corrêa, 1921; Campbell, 1925; Della Serra, 1976; Diamond [cited by Hanke, 1987]). This fact explains the designation of tubercle of Carabelli as the "sign of Sabouraud." However, authors like Cruet, Jeanselm, Mozer, Chenet, Bardoin, De Granda, Gallipe and Mantoux did not agree with this theory (Campbell, 1925; Della Serra, 1976).

NOMENCLATURE

Numerous synonyms have been used to refer to this dental trait. We encountered the designations of ectocone of Chardin, ectocone of Trihland, pericone of Stehlin (Ferreira, 1996), *tuberculum anomalum*, fifth lobe, supplementary cusp, fifth tubercle (proposed by Cruet after descriptions by Malassez and Magitot [Della Serra, 1976]), accessory cusp, mesiolingual elevation or prominence, fifth cusp, *tuberculum Carabelli*, Carabelli's anomaly, tubercle and cusp of Carabelli (introduced by Sömmerling [cited in Dokládal, 1983] in honor of Carabelli's discovery), protuberance of Carabelli, Carabelli's complex, polymorphism of Carabelli (Mizogushi, 1993), *tuberculus anomalus* (used by Georg Carabelli Edlen von Lunkaszprie [Campbell, 1925]), mesiolingual tubercle, paramolar tubercle, odd tubercle, and atrophied cusp (Hanke, 1987).

Editor's note: Mr. Correia and Ms. Pina's paper was awarded Honorable Mention for 2001 in the Albert A. Dahlberg student research competition sponsored by the Dental Anthropology Association.


André Correia and Carla Pina

Functionally, terms like Carabelli's cusp, fifth cusp, atrophied cusp, supplementary cusp and accessory cusp are incorrect given their position on the lingual side of the crown, which is about 2 mm lower than the occlusal level (Fig. 1B) (Woelfel, 1997). In the present study, the term *Carabelli's tubercle* is used to designate this morphological characteristic.

During tooth odontogenesis, some cells of the inner enamel epithelium of the crown base (*zona cingularis*) retain a proliferative capacity. The development in this region of supernumerary cusps and styles is easily understood, as for example, the tubercle of Carabelli (Abrams, 1992; Pinkerton, 1999; Scott and Turner, 2000). However, in case of an absence of development of a lingual cingulum, this region may or may not form a Carabelli groove (Abrams, 1992).

CLASSIFICATION

In contrast to the stability of its position on the molar, this trait presents various forms, which makes its pattern difficult to establish. Initially, references to this characteristic only considered the presence-and-absence of the tubercular and lobular forms (nominal scale).

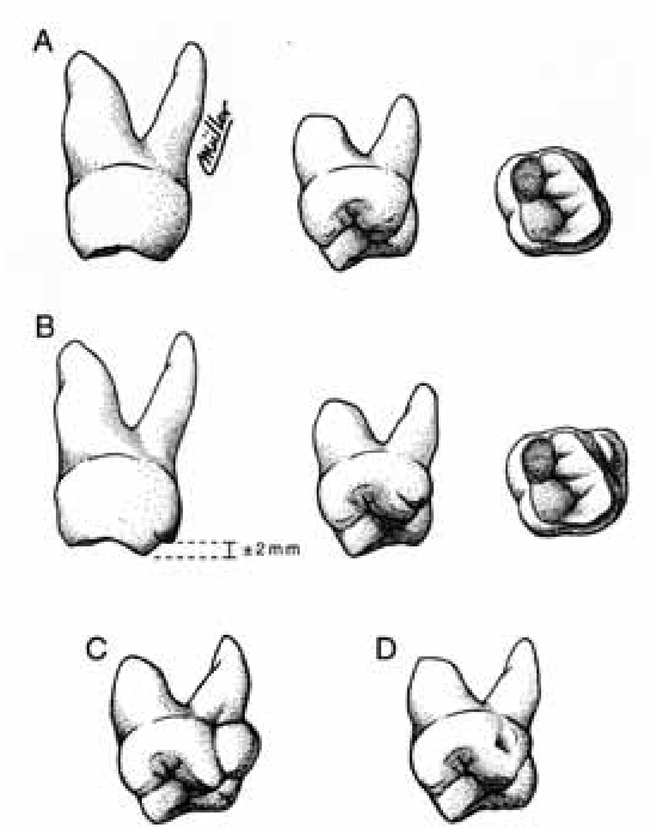

Fig. 1. Views of a maxillary molar showing (A) mesial, mesial-occlusal and occlusal aspects of a tooth without the Carabelli trait, (B) relationship of the Carabelli tubercle on the mesial-lingual crown aspect (with measurement of cusp height relative to the crown's occlusal surface), (C) a mesial-occlusal view of a molar with Carabelli's lobule, and (D) a mesial-cclusal view with Carabelli's groove. (Illustration by Daniel M□ller, MA.)

However, Batujeff (cited in Kraus, 1959) considered pits and grooves to be manifestations of this feature. This perspective has been supported by other investigators, like Dietz (1944) and Della Serra (1951).

Dahlberg (cited in Scott and Turner, 2000) developed an ordinal scale with eight grades, from trait absence (0) up to a large tubercle (7). All the grades formed a continuum, varying in the degree of expression, as in the ordinal grades developed by Mizoguchi (1993). Perhaps because of the variety of classifications described in the literature, it is difficult to find precise morphological criteria that permit objective comparisons among studies. Using the classification of Dietz (1944), we have compiled the data presented in Table 1.

POPULATION FREQUENCIES

The tubercle of Carabelli is a phylogenetically ancient characteristic (Pereira, 1995). Jeanselm and De Granda (cited in Della Serra, 1976) documented the presence of this tubercle in skulls of all eras, the first author reported trait from the remains of *Adventicious denticulus* which was a lemur. It also has been reported in specimens of *Pithecanthropus sp*. and in other Anthropoids (Corrêa, 1921). Gregory (cited in Campbell, 1925) demonstrated the importance of the tubercle of Carabelli in the structural and phylogenetic relationships between primitive and more recent Anthropoids and Hominoids. Schwartz et al. (1998) studied the tubercle of Carabelli in the Australopithecus (*A. africans* and *P. robustus*) and De Terra (cited in Corrêa, 1921) considered this dental characteristic as a sign of civilized races, of which the Krapina man was used as an example.

From an evolutionary perspective, the tubercle of Carabelli tends to disappear in concert with reduction of the hypocone (Fig. 1A), resulting in simplification of the occlusal surface (Reid et al., 1991; Mizoguchi, 1993; Hillson, 1996; Tsai et al., 1996).

From a functional point of view, the tubercle is a compensatory structure of evolution reducing the mesiodistal diameter of upper molars as a result of excessive biomechanical stress exerted on the first molar (Mizoguchi, 1993; Tsai et al., 1996).

The difference in the expression of the Carabelli's tubercle in the primary and permanent dentitions is a decreased frequency but with an elevated proportion of the tubercular form in the permanent dentition.

As an anthropological measure, the tubercle of Carabelli, in conjunction with other morphological traits has been used for the evolutionary study of races (De Castro, 1989; Johnson, 1999; Bailey, 2000). Some characteristics of dental crowns were present or absent in various racial groups, with a great frequency

TABLE 1. Frequency of different expressions of Carabelli's tubercle

Author(s)	Tubercle	Lobe	Groove	Pit
Campbell (1925)	5.0	5.0	90.0	--
Campbell (1925)	23.8	35.7	40.5	--
Cohen (cited in Della Serra, 1976)	17.4	--	--	44.8
Della Serra (1976)	5.3	2.1	30.1	23.6
Dietz (1944)	31.1	55.3	8.0	5.5
Ferreira (cited in Della Serra, 1976)	29.2	--	29.2	--
Ferreira (cited in Della Serra, 1976)	18.1	--	33.3	--
Sharma (1983)	0.0	--	5.8	--

that were viewed as identifying characteristics of these groups. For example, in Caucasians the frequency of tubercle of Carabelli is elevated, while the same was not true of the Mongol and in the Melanesian races where the tubercle can reach the size of the other cusps (Kraus, 1959; Abrams, 1992; Tsai et al., 1996). Consequently, the trait can be relevant for dental and racial identification (Table 2).

In studies where the presence or absence of tubercle of Carabelli was quantified, the trait is found more commonly on the first molar. Occurrence of the tubercle on the second molar only occurs when it is also encountered on the first molar (Dietz, 1944).

The differences in population frequency should be considered in terms of differential frequencies of genes regulating the velocity and duration of mitotic cell activity of the *zona cingularis* (Kraus and Jordan cited in Scott and Turner, 2000).

At the beginning of the last century, G.V. Black (cited in Bailit, 1980) confirms that this dental trace "was hereditary, appearing regularly in children's teeth, when it was present in the parent's teeth. Also it is found, in a modified way when it is present in only one progenitor."

Kraus (1959), in his first analysis, suggested a model of simple autosomal transmission corroborated by other studies. He also considered, that the homozygous condition was responsible for a marked tubercle and that the heterozygous genotype determined the presence of small grooves, pits, tubercles or lobules (Figs. 1C and 1D). Much later, Lee and Goose (1972), Townsend and Brown (1981) and Pinkerton et al. (1999) proposed a multifactorial model in which, in spite of a strong genetic contribution, the environmental factors contributed to the expression of the characteristic. The high bilateral expression of Carabelli's tubercle in twins (Townsend and Martin, 1992; Pinkerton et al., 1999) and the high level of symmetry that has been found in various studies (Dietz, 1944; Scott, 1980) emphasize the importance of a genetic contribution to trait expression, without overlooking environmental factors.

The results of studies by Mizoguchi (1977), Townsend (1981), Kaul and Prakash (1981), Scott and Potter (1983), Tsai et al. (1996), and Pinkerton et al. (1999) document the existence of sex dimorphism in the expression of the tubercle of Carabelli, namely that there is greater prevalence in males. On the other hand, Scott (1980), Castro (1989) and Tsai et al. (1996) did not report any significant difference between the sexes.

SUMMARY

The tubercle of Carabelli is a morphological dental characteristic with relevance in anthropological and forensic studies. The study of its distribution

TABLE 2. Frequency of Carabelli's tubercle on the maxillary first molar

Author(s)	Samples	Frequency (Percentage)
Bang (1972)	Eskimos, Alaska	42.7
Campbell (1925)	Aboriginal Australians	33.2
Corrêa (1921)	Portuguese	13.5
Della Serra (1976)	White Australians	54.4
Dietz (1944)	American soldiers	72.3
Dokládal (198.3)	Romanian	52.0
Ferreira (cited in Della Serra, 1976)	Whites, Brazil	58.4
Ferreira (cited in Della Serra, 1976)	Negroes, Brazil	51.4
Hanke (1987)	Brazilian population	58.3
Kaul (1981)	Jat, India (primary teeth)	79.8
Kaul (1981)	Jat, India (permanent teeth)	61.9
Reid (1991)	Kwengo	57.0
Scott (1980)	Eskimos and Aleuts	47.3
Scott (1980)	Indians, Asia	62.2
Scott (1980)	Indians, American Southwest	66.9
Scott (1980)	Easter Island	35.7
Scott (1980)	Solomon Islands	44.2
Scott (1980)	Hawaiians	45.4
Scott (1980)	American White	85.0
Scott (1980)	Bantu	73.1
Scott (1980)	Bushmen	70.3
Scott (1980)	Whites, South Africa	74.9
Scott et al. (1983)	Pima Indians	74.0

and frequency among populations demonstrates its importance in the research of human evolution. The documentation in the literature regarding its frequencies has permitted the estimation of phylogenetic relationships between populations separated by geographic conditions.

ACKNOWLEDGEMENTS

The authors gratefully acknowledge the support of Professor Américo Afonso with respect to the elaboration of this article.

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Minutes of the Dental Anthropology Association Business Meeting, March 29, 2001 - Kansas City, MO

CALL TO ORDER:
The meeting was called to order at 5:00 pm, by President Edward Harris.

OLD BUSINESS:
No items were discussed.

NEW BUSINESS:
1. Election of new officers. Two new officers were elected: Simon Hillson (Executive Board member) and Diane Hawkey (Secretary-Treasurer). Hawkey is reprising her role as a DAA officer, having held the Secretary-Treasurer office before in 1990-1992. The out-going officers (Stephen Reichardt, Secretary-Treasurer and David Gantt, Executive Board Member) were officially thanked by Harris for their valuable contribution to the DAA.

2. Albert A Dahlberg Student Prize. The winners of the 2001 AA Dahlberg Student Prize were announced by Sue Haeussler, Editor of Dental Anthropology. First Prize ($200.00) was awarded to Matthew Tocheri (Arizona State University) for his paper entitled: "The effects of sexual dimorphism, asymmetry, and inter-trait association on the distribution of 13 deciduous traits in a sample of Pima Amerindians," Two Honorable Mention Awards were given ($50.00 each), to Tammy R. Greene (University of Alaska Fairbanks) for "Dental Paleopathology of the Ray Site [12W6]" and to Andre Correia (University of Porto, Portugal) for "Tubercle of Carabelli. A review". All prize winners also receive a year's membership in the DAA, and will have their articles published in the journal. [*Editor's note*: These three papers are published in this issue of *DA*.]

3. Dahlberg Prize Donations. On behalf of the DAA, Haeussler extended the Association's heartfelt thanks to Thelma Dahlberg for her generous donation of $1,000 to the AA Dahlberg Student Prize Fund, and to all DAA members who have contributed to the fund this past year.

4. Dental Anthropology Editor's report. Haeussler will be retiring as Dental Anthropology Editor in 2002. Edward Harris (who will finish his term as President) has agreed to become the new Editor. A new cover/logo for the Dental Anthropology journal was presented for the members' comments. The design was provided to the DAA courtesy of Jeff Irish (owner of Concept and Design, Inc. in Nicollet, MN and brother of President-Elect Joel Irish). Comments were quite favorable and plans are made to incorporate the new design in future issues. The outstanding job done by Debbie Guatelli-Steinberg, who has acted as Book Review Editor for the Dental Anthropology journal this past year, was noted and warmly appreciated.

5. Secretary-Treasurer's Report. [Reichardt was unable to attend the meeting to present the report. Please see the addendum below by Hawkey for the current status of the DAA Treasury and Membership.]

6. Additional topics. Hawkey noted that 11 April 2001 marks the 15th Anniversary of the founding of the DAA. Harris suggested that the Association consider sponsoring a symposium at next year's AAPA meeting and called for topic suggestions. Several possibilities were mentioned, including dentition and human variation, indicators of stress, and use of population distance studies/phenetic analyses. An Executive Board decision was made to use DAA funds to purchase a new printer and a fax/answering machine. Harris offered to update the DAA website and to coordinate with AAPA to publish in their business report the names of the winners of the Dahlberg Prize

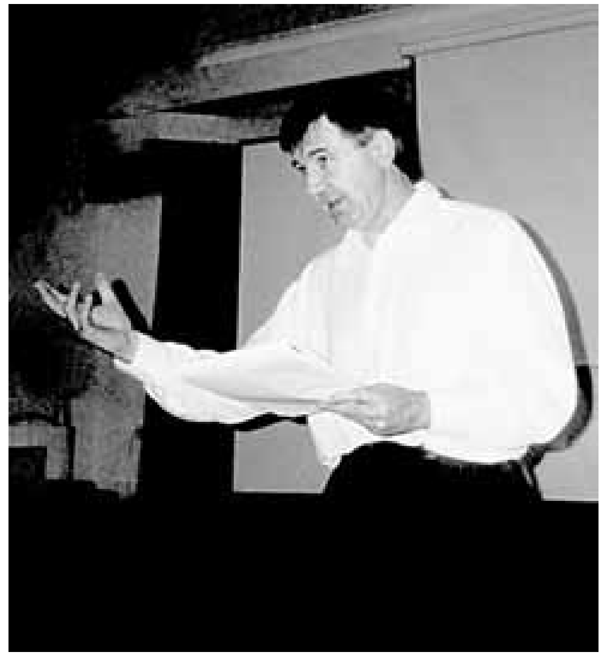
ADJOURNMENT:
The meeting was adjourned at 5:28 pm by Harris, to allow members to attend the AAPA plenary session scheduled at 5:30. This meeting holds the record as the fastest business meeting in DAA history!

ADDENDUM:
The Secretary-Treasurer report was unavailable at the time of the meeting, but upon taking over the duties of office, Hawkey reports that as of March 29th, the total amount in the DAA treasury is $3,792.31. There are 256 active members.

Submitted by: Diane E. Hawkey
DAA Secretary-Treasurer

Dental Morphology Meeting in Sheffield a Big Success

Edward F. Harris
University of Tennessee, Memphis



Dr. Alan Brooks hosted the Symposium, held on the campus of the University of Sheffield

The 12th International Symposium on Dental Morphology was held with great success in Sheffield, England, this past August. Hosted by Alan Brook, who somehow found time from his duties as Dean of the Dental School, the meeting was attended by over 80 dental scientists from throughout the world.

The theme of "Dental Morphology" always has been interpreted quite loosely by this group. Papers actually run the gamut from morphology, to tooth size, histology, computer imaging, theory, growth, development, and beyond. The scientific sessions were wonderfully counterpointed by dinners, tours of the local landscape—including castles—chats with the Mayor and Master Cutler of Sheffield, and extensive dissertations on the history of steel-working in the region (including a banquet at the Kelham Island Industrial Museum). Wonderful times were had by all!

The Dental Symposia have been held in many venues since the first in 1968 (see Table, page 25), but always outside of North America. The participants have successfully resisted any form of organization. There is no official membership, no dues, no by-laws, no elected officers. Courageous individuals have come forward to take on the considerable task of hosting the meeting each three years, but participation remains egalitarian.

Contributors this year were given the option of submitting their papers ahead of time for review and publication in the proceedings. A total of 30 papers were published in *Dental Morphology 2001*, which was available for distribution at the meeting. This hard-bound, well-formatted book (350 pages) published by the Sheffield Academic Press, Ltd. has the papers arranged into six sections, 1) dental anthropology, 2) evolution, 3) ontogeny, 4) technology, 5) morphological integration, and 6) genetics. There's valuable information here for all dental scientists regardless of specialty. Details for ordering this book are provided on page 32. These papers also are available on CD. Additionally, please note that the book and CD from the 11th Symposium (Oulu, Finland) can still be purchased (details also on page 32).

Dr. Percy M. Butler provided the keynote talk at the symposium.

The single-session, four-day meeting was attended by anthropologists, dentists, zoologists, paleontologists, embryologists, computer specialists, and others. The relatively small but varied group is reminiscent of the eclectic meetings of physical anthropologists and of dental researchers several decades ago when smaller memberships fostered greater collegiality. This great learning environment—intercuspated with a joyful balance of bon vie provided by the hosts—have made these symposia anticipated events that are likely to live well into the future despite the absence of any formal infrastructure. The organizing committee of the Sheffield meeting is to be commended for an onerous job done to perfection.

Group photograph of the participants at the 12th International Symposium on Dental Morphology, Sheffield, U.K. A total of 46 papers were delivered from the podium during the four-day meeting; 30 of these papers were included in the published volume.

TABLE. The chronology of the 12 Dental Morphology Symposia held over the past 36 years (data furnished by John Mayhall)

Meeting	Year	Location	President
1	1965	Fredensborg, Denmark	P. O. Pedersen
2	1968	Englefield Green, UK	Percy M. Butler
3	1971	Brussels, Belgium	H. Brabant
4	1974	Cambridge, UK	Percy M. Butler
5	1979	Turku, Finland	P. Kirveskari and L. Alvesalo
6	1982	Rekyjavik, Iceland	G. Axelsson
7	1986	Paris, France	J-P. Santoro
8	1989	Jerusalem, Israel	Pat Smith
9	1992	Florence, Italy	B. Chiarelli and J. Moggi-Cecchi
10	1995	Berlin, Germany	R. J. Radlanski
11	1998	Oulu, Finland	Lassi Alvesalo
12	2001	Sheffield, England	Alan Brook

Book Reviews

DENTAL MORPHOLOGY 1998: PROCEEDINGS OF THE 11th INTERNATIONAL SYMPOSIUM ON DENTAL MORPHOLOGY. Edited by John T. Mayhall and Tuomo Heikkinen. Oulu: Oulu University Press (paperback), 1999. 492 pp. ISBN 951-42-5481-3. $100, including shipping.

The recent volume resulting from the International Symposium on Dental Morphology held in 1999 in Oulu, Finland exemplifies John Mayhall's observation that: "…dental morphology means many things to many people." The 55 papers in this volume cover a wide range of subjects and are divided into six sections: Dental Anthropology, Dental Evolution, Ontogeny, Technology, Morphological Integration within the Dental and Craniofacial Complex, and Dental Genetics. Each section's set of papers provides an interesting mixture of the latest research in a particular field.

The section on "Dental Anthropology " is the largest with 23 papers covering a variety of topics from traditional population comparisons (Nagai and Kanazawa) to development and eruption (Antoine et al. and Smith et al.). The paper that embodies the spirit of this section is Mayhall's. In his paper, Mayhall puts forth a "plea" for dental morphology researchers to remember that in many cases non-metric traits should not be scored as "present or absent" because they exhibit a range of variation in a population. Mayhall connects dental anthropology's past research with its future with his six recommendations:

1. Give complete frequencies for each identifiable variation
2. Use recognized standards for recording trait variations
3. Do not use presence/absence unless trait is truly dichotomous
4. Indicate the ranges of variation
5. Indicate the size of each category of variation
6. If results must contain combined data:
    a) indicate the variability within the group and sub-groups
    b) indicate the sources of variation
    c) indicate the provenance of the sub-groups
    d) indicate the sub-group size.

(Mayhall 1999:46)

The second section, "Dental Evolution," consists of 11 papers, the majority dealing with species other than *Homo sapiens*. Topics covered include gross morphology (Turnbull et al., Mazza) and the development of Hunter-Schreger Bands (Suzuki et al.). One of the few papers to examine *Homo sapiens* in this section is Niskanen's, "The Origin of the Anatomically Modern Human Face through Differential Rates of Tooth Size and Facial Size Reduction," in which two behavioral models are tested as possible explanations for the anatomically modern *H. sapiens* pattern. This paper is a classic example of a biocultural examination of human evolution.

The seven papers in the "Ontogeny" section focus mainly on the developmental aspects and morphology of enamel and dentin of several different species. Harris et al.'s paper examines sexual dimorphism in the enamel and dentin thickness of human deciduous molars derived from different populations. One interesting aspect of this paper is the level of study: most studies of dental sexual dimorphism are confined to macroscopic analysis, while Harris *et al.* examine the actual dental tissue which may cause sex differences in the dentition.

While the fourth section, "Technology," is one of the smallest sections, with just four papers, it is also one of the most interesting. In each paper, a new technique for study is outlined and explained. The first and last papers present new imaging systems for dental measurements in comparison to standard techniques. The paper by Smith et al. examines growth of the DEJ and outer enamel surface of hominid permanent and deciduous molars using C-T scans. The paper by Willmot et al. examines developmental defects and post-eruptive defects in the enamel using imaging analysis.

The fifth section, "Morphological Integration within the Dental and Craniofacial Complex," consists of four papers dealing with the relationships of the dentition with other anatomical structures, e.g. the cranium. Other papers in this section are devoted to how the dentition is affected by biological processes, such as aging.

The last and smallest section, on dental genetics, contains two papers. The first paper, by Townsend, Dempsey and Richards, examines genetic and environmental contributions to the metrics (and one non-metric trait) of the dentition in twins. The second paper, by Heikkinen et al., is an investigation of the effects of race and sex on symmetry of tooth eruption in different populations.

There is no easy way to classify this volume because of its eclectic mix of subjects, but it will surely fulfill the editors' hopes to stimulate interest in various research areas. Unfortunately, since the majority of the pictures, diagrams, and charts are re-creations of slides from the presentations, the quality varies from paper to paper. Overall, however, the photographs are of superior quality, and function to enhance the text. This volume will serve as an exceptional resource: it provides the reader with the latest findings and technologies in diverse areas of dental anthropology research.

LOREN R. LEASE
Department of Anthropology
The Ohio State University
Columbus, OH 43210

BIOLOGICAL ANTHROPOLOGY OF THE HUMAN SKELETON. Edited by M. Anne Katzenberg and Shelley R. Saunders. New York, Toronto. Wiley-Liss, Inc., 2000. 504 pp. ISBN 0-471-31616-4. $80.75, cloth.

This exciting and comprehensive volume, detailing methods of bioanthropological research as applied to the human skeleton, brings together 21authors in 16 chapters. An initial impulse is to compare this work with the 1992 book edited by Saunders and Katzenberg, *Skeletal Biology of Past Peoples: Research Methods*, as many of the same authors appear in both volumes. However, to characterize this book as an updated version of the 1992 volume is to grossly misrepresent this work. On closer inspection, it is clear that the editors have adopted a mature approach to the biocultural study of the human skeleton. Many contributors are cautionary, but not pessimistic as they discuss in detail the limitations associated with bioarchaeological research, while other chapters portray practical applications for describing and analyzing biological data. The definitive theme of the book is to report advanced methods in skeletal and dental research, however a welcome addition is the introductory chapter on ethics in bioarchaeology.

The book is divided into five parts, with the first section consisting of two chapters devoted to theory and application in studies of past peoples. The remaining four sections emphasize current perspectives for specific areas of skeletal and dental anthropology such as morphological analyses, paleopathology, chemical analyses of bone (including aDNA research), aging techniques, and quantitative applications.

In the first chapter, P. Walker sharply focuses the reader's attention to bioethics and addresses the moral conflicts associated with bioarchaeological research. Walker presents the historical background for research on human remains highlighting the paradoxical position of bioarchaeology with its roots both in medicine and anthropology (p. 3). One strength of this chapter is that Walker provides a framework for discourse between bioarchaeologists and indigenous populations—a discourse that employs respect born from historical perspective and understanding. In the second chapter, D. Ubelaker examines forensic anthropology. Again, a historical background provides a basis for understanding that the "theoretical approach employed in forensic anthropology basically involves a broad anthropological population perspective applied to the individual" (p 49). Ublelaker reviews the methods employed in forensic anthropology and supports that the future of forensic research is bright.

Part two consists of five chapters concerning morphological analyses and age changes. C. Ruff presents an overview of biomechanical research as applied in the reconstruction of past human behavior. He discusses different methods for structural analysis of long bones and reviews the exciting results of biomechanical studies as applied to long term evolutionary trends, microevolutionary changes and variation within an individual's lifetime. Students looking for a detailed discussion on dental morphology recording strategies will be thrilled to read J. Mayhall's chapter. Mayhall provides extensive descriptions of morphological methods and notes the strengths and limits of each technique. He emphasizes that dental morphological studies should employ methods that are consistent, easily achievable, and comparable with other studies. S. Saunders takes a careful look at subadult growth studies as indicators of past population health and applies a practical perspective for addressing some of the problems associated with these studies. She explores issues such as the recovery of an unbiased sample of subadults, the limits of sexing subadults and the inherent difficulties associated with age estimation techniques. Although cautionary, Saunders stresses that the potential of data recovered from living individuals, forensic cases, historic cemeteries as well as aDNA techniques and histology may serve to clarify age estimation in subadult skeletons and provide population specific databases for testing growth study assumptions. C. FitzGerald and J.C. Rose discuss exciting methods for assessing subadult age using dental growth markers. The authors provide a generous review of dental anatomy, which allows the reader to understand how enamel is formed and thus how enamel microstructures can be used to determine subadult age. A major strength of this chapter is its practical focus, which includes discussions on preparation of tooth samples, microscopy as well as image analysis. A. Robling and S. Stout review the physiology and histomorphology of cortical bone and provide a synthesis of histomorphometric age estimation research. The authors include discussions of several factors that affect histological age estimates at both the physiological and methodological level. Again, the practical perspective must be applauded which includes worked examples of age estimation methods in the appendix.

Part three presents three chapters detailing current methods and research in prehistoric health and disease. N. Lovell examines several methods used in paleopathological research such as gross macroscopic observations, radiographic methods, computed tomography, magnetic resonance imaging, endoscopy, microscopic methods, and biochemical methods. She cautions that although paleopathology is the discipline that "aims to reconstruct the history and geography of disease" it is mostly restricted to lesions from trauma and chronic conditions (p. 217). She states that researchers must consider the larger role of disease as factors in biocultural evolution in order for paleopathology to have relevance outside our scientific community. S. Hillson reviews methods for evaluating dental pathology and provides extensive discussions on developmental defects of enamel, dental wear, dental calculus, caries and periodontal disease. Hillson reminds the reader that the pathologies reflected in the human mouth are linked and their pattern of progression is complex and can sometimes interact in contrasting ways. Therefore it is important that the recording systems and analyses of dental pathology reflect accurate life processes. Hillson provides excellent advice for recording and evaluating dental data and presents a scoring system for caries and periodontal disease (pp. 273-280). The final chapter in this section reviews palaehistological methods as a technique in evaluating health and disease. S. Pfeiffer stresses that the size and organization of osteons, haversion canals, and other bone microstructures provide telltale clues in reconstructing past human life. Pfeiffer describes methods for obtaining, preparing and analyzing samples. She also presents research from different studies that employ palaehistological methods in evaluating bone structure variation, health and disease.

Part four, Chemical and Genetic analyses of Hard Tissues, includes three chapters that explore stable isotope, trace element, and ancient DNA analyses. M.A. Katzenberg provides a mature look at stable isotope analyses and how these studies are integrated with other biocultural questions and themes. She reviews methods for obtaining samples and presents research studies that employ stable isotope techniques to reconstruct diet, determine infant weaning strategies, identify pathological bone changes and identify residence and migration patterns. M. K. Sandford and D. S. Weaver present a frank discussion on elemental analyses in skeletal research, emphasizing the confounding affects of diagensis. The authors review bone chemistry, biogenic and diagenetic processes and conclude with a plea for "genuine interdisciplinary collaborations and more specialized, up-to date training of our students" (p. 344). A. C. Stone reviews the methods for recovering ancient DNA, drawing attention to how DNA is preserved and modified in the original environment and during subsequent extraction. Stone cautions that there are still challenges within the field, such as experimental design and contamination of samples, but also demonstrates the potential rewards for this area of research. Through numerous examples, Stone demonstrates how molecular archaeology can be used as supplemental verification for traditional anthropological questions or provide unique evidence such as in the identification of specific pathogens.

The final section of the book contains three chapters that emphasize quantitative methods and population studies. M. Pietrusewksy presents a non-technical discussion for using multivariate statistical methods in analyzing morphometric data. Starting with the assumptions used in biological distance studies, Pietrusewksy provides a step by step review of quantitative techniques and ultimately focuses on current computer statistical packages. Examples of Pietrusewksy's personal research in craniometric analyses provide excellent references for use in comparison studies. M. Jackes offers a thought-provoking discussion on adult age determination and portrays a clear depiction of the crises that bioarchaeology faces without accurate age estimates. Jackes exhaustively reviews all techniques used in evaluating age at death and provides a test of each technique. She maintains that skeletal indicator stages are stages of skeletal change and not direct indicators of chronological age. Jackes concludes that statistical techniques cannot take the place of accurate descriptive methods and that any analyses of adult age must employ seriation of adults by many different stage methods scaled by cemental anulations whenever possible. G. R. Milner, J. W. Wood and J. L. Boldsen revisit several questions that are fundamental to the field of paleodemography and at the center of skeletal research in general. The authors present a pragmatic approach to understanding problems of sampling, age and sex estimation, population non-stationarity, heterogeneous frailty and selective mortality. They promote the use of parametric mortality models, maximum likelihood estimation, and other statistical modeling methods as strategies to provide a more reliable estimate of life and death in past populations.

Bioarchaeology is a highly specialized discipline and students must be well versed in the methods of chemistry and statistics as well as in the discourse of bioethics. This book addresses these concerns by providing in unambiguous detail advanced methods for the analysis of bones and teeth. Although many of the methods highlighted in this volume employ destructive techniques, it is evident that students new to graduate research as well as international scholars and senior researchers will find this book a useful tool. Indeed, every chapter contains an extensive bibliography as well as practical, reality-based approaches to skeletal research. Each author has provided well-written and insightful contributions, with only a handful of errors mainly contained to captions, missing references and a few proofing errors within the text. It is clear that this book will be a mainstay for bioanthropology graduate reading lists and will acquire a welcomed spot on many bioarch-laboratory bookshelves.

TERI TUCKER
Department of Anthropology
The Ohio State University
Columbus, OH 43210

PERSPECTIVES IN HUMAN BIOLOGY, VOLUME 4(3): DENTO-FACIAL VARIATION IN PERSPECTIVE. Edited by Grant Townsend and Jules Kieser. Series Editor: Charles Oxnard. Centre for Human Biology, Department of Anatomy and Human Biology, University of Western Australia (paperback), 1999. 172 pp. ISBN: 0-86422-934-8.

Dento-Facial Variation in Perspective consists of 20 peer-reviewed articles based on presentations made at the Joint Conference of the Australian Society for Human Biology (ASHB) and the Commission of Human Ecology of the International Union of Anthropological and Ethnological Sciences (IUAES) held in Adelaide in 1997. These concise papers, incorporating state of the art technology and powerful statistical models, are organized around four central themes: the influences of genes and environment on dento-facial variation; dental wear; dento-facial variation across human populations; and the use of new imaging techniques in morphometric analyses. Unifying the contributions to this volume is the useful theoretical perspective of the dento-facial complex as a functional, dynamic system.

John Mayhall's keynote address focuses on the problem of using dental complexes to understand population affinities in the absence of a firm understanding of the interaction of genetic and environmental influences on variation in dental morphology. Mayhall's address is a lead-in to several papers dealing with the interaction of genetic and environmental influences on dento-facial variation.

Authors Dempsey, Townsend, and Martin demonstrate the effectiveness of structural equation modeling to determining the genetic basis of crown size. Among other advantages, this method improves on traditional approaches by separating common (or family) environments from genetic factors. Of all the permanent teeth examined, the canine and first premolar appear to be most strongly influenced by non-additive genetic effects while maxillary first molars are most strongly effected by common environment. In their paper, Pinkerton and colleagues find that concordance for the Carabelli trait is higher in monozygous (MZ) as opposed to dizygous (DZ) Australian twins, reflecting the strong influence of genetic factors on this trait. Thomas's and Townsend's study on interdental spacing in the primary dentition again compares MZ and DZ Australian twins, finding higher concordance of spacing type in MZ twins. The Australian twins participating in these studies of dento-facial growth were examined for concordance of handedness by Dempsey et al., who found no association between handedness and zygosity. While this study is well-designed and interesting, it is not clear why the editors chose to include it in a volume devoted to the subject of dento-facial variation.

Dento-facial asymmetry is the subject of papers by Townsend, Dempsey, and Richards (asymmetry in the deciduous dentition) and Winning, Brown, and Townsend (human facial asymmetry). In the first of these papers, the authors find no evidence for greater asymmetry in the deciduous teeth of twins relative to singletons, even though it might be supposed that twins compete for nutrition during gestation, experiencing more stressful intrauterine environments than singletons. In the second of these papers, facial asymmetry is found to exhibit extensive individual variability during growth, but there is no overall trend for changes in facial asymmetry with increasing age.

Genetic abnormalities can reveal important aspects of dental development, as is shown in papers by Narayanan, Smith, and Townsend (cleft lip and palate) and Townsend and Alvesalo (Klinefelter's syndrome). The authors of the first paper find that fluctuating dental asymmetry is not only elevated in the region of the cleft but also in other regions of the dentition, indicating both local and systemic developmental disruption. The authors of the second paper report greater intercupsal dimensions in the premolars of 47,XXY individuals relative to normal controls, consistent with Alvesalo's previous research demonstrating the influence of the X chromosome on enamel thickness.

The next group of papers examines dental wear as affected by craniofacial morphology, tooth-grinding, diet, and culture. Authors Richards et al. find significant relationships between tooth wear patterns and craniofacial morphology in three Australian populations. Kaidonis, Townsend, and Richards show that dental microwear not only results from diet and culture but from tooth-grinding, while Springbett et al. find, in their study of Australian Caucasians and Aboriginals, that wear processes differ between the two groups, reflecting cultural and dietary differences.

Five papers documenting dento-facial variation across populations include studies of Cook Islanders, South Pacific Peoples, Mioriori, Maori, Chinese, and Caucasians, substantially broadening the perspective of this volume, which, until this point, relies heavily on Australian populations. Kageyama, Mayhall, and Townsend use moiré contourography and digital image analysis to study three-dimensional occlusal form in the dentition of Australian aborigines. Kondo and colleagues find sex differences in the talonid dimensions but not in the trigonid dimensions of Cook Islanders' mandibular molars, perhaps reflecting the fact that the talonid forms later in development than the trigonid. In their paper, Aboshi et al. find that Fijians are less like Kirbatians and Western Samoans, who are more like each other, in the size and shape of their dental arches. An interesting paper by Kieser and colleagues examines the relationship between basicranial flexion and glenoidal depth in Moriori, Maoiri, Indians, and Caucasians finding that the glenoidal fossa deepens as the basicranial angle decreases. Data derived from a CT scan of STS 5 (A. africanus) conforms to this trend. The authors believe that the vulnerability of the TMJ to dysfunction could be related to the deepening of the glenoid in hominid evolution, in turn a result of the progressive increase in cranial flexion. This cross-cultural section concludes with Tasman Brown's paper on providing standards for soft tissue profiles of Caucasians and Chinese for use in clinical settings.

The last three papers of this volume concentrate on the use of new imaging techniques to analyze craniofacial structures. While these papers are of clinical relevance, the techniques described will certainly be of interest to dental anthropologists. Chintakanon et al. show that magnetic resonance imaging is a highly effective method of describing variation in TMJ morphology. Netherway and colleagues use computer tomography for characterizing the human craniofacial skeleton in three dimensions, and Abbott et al. use computer tomography to demonstrate that intracranial volume is not smaller than normal in subjects with non-syndromal craniosynostosis while it is significantly larger than normal in those with syndromal craniosynostosis.

Overall, this volume in the Perspectives series coalesces important recent research on the dento-facial complex, with emphasis on the interaction of genes and environment. While many of the studies involve research on Australian populations, the editors have included studies on other populations as well. This volume applies powerful new statistical methods and imaging techniques to enhance the understanding of gene-environment interactions and the analysis of variation in dento-facial form. Owing perhaps to space constraints, some studies have only brief discussions, and this is in one respect unfortunate because the studies themselves are so interesting. However, concise statements of research problems, materials, methods, and results highlight the many significant and illuminating aspects of these studies.

DEBBIE GUATELLI-STEINBERG
Department of Anthropology
1218 University of Oregon
Eugene, OR 97403-1218

THE ALBERT A. DAHLBERG PRIZE

RESEARCH COMPETITION in DENTAL ANTHROPOLOGY

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. Manuscripts must be received by January 31 of the year that the prize will be awarded, in this case January 31, 2003. The format must follow that of *Dental Anthropology*, which is similar to the style of the American Journal of Physical Anthropology printed in 2002, Volume 117(1). The Guide to Authors also is available at the web site for the AJPA (http://www.physanth.org) or by e-mail from the editor (ajpa@osu.edu).

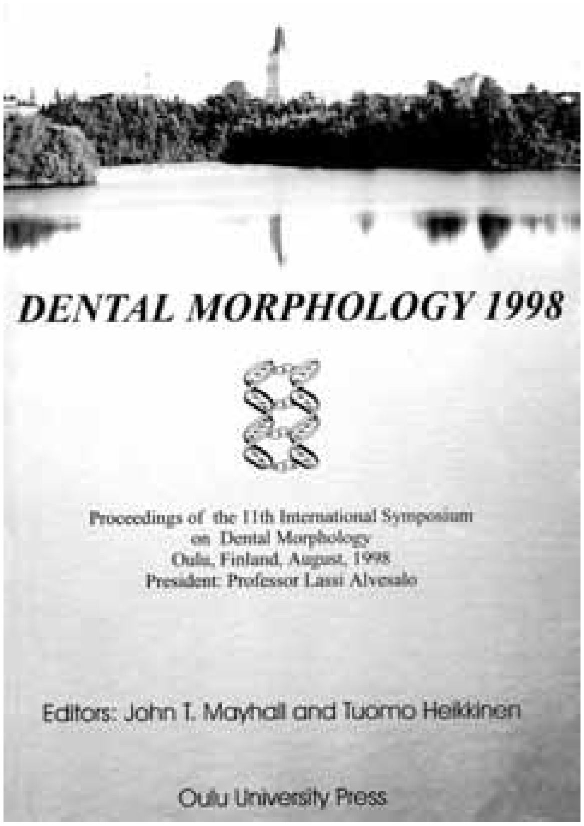
The manuscript should be accompanied by a letter from the student's supervisor indicating that the individual is the primary author of the research and the paper. Multiple authorship is acceptable, but the majority of the research and writing must be the obvious work of the student applying for the prize.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

Dr. Joel D. Irish
Department of Anthropology
University of Alaska
Fairbanks, AK 99775-7720 U.S.A.

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 2003, the meeting will be held in Tempe, Arizona. The date, time and venue will be announced by the AAPA.

PLEASE ADVERTISE THIS COMPETITION TO YOUR STUDENTS

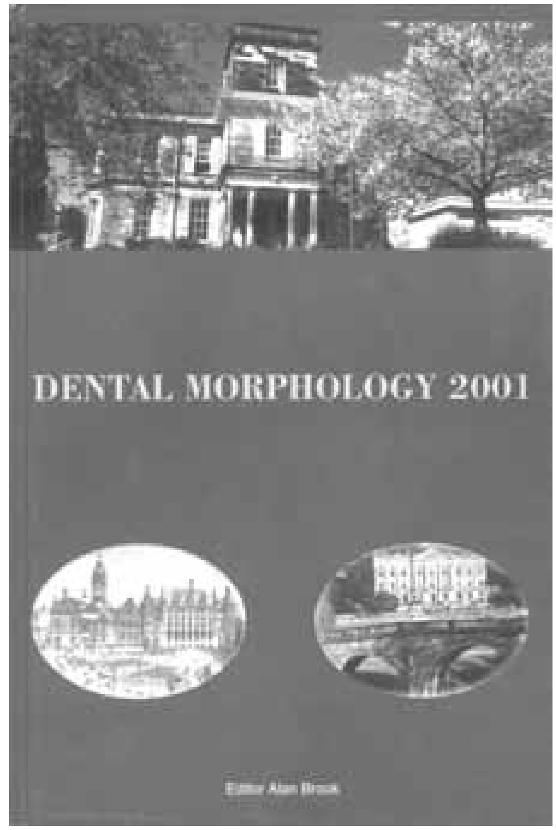


A few copies of the bound volume and companion CD from the **11th International Symposium on Dental Morphology** are available from the editors, John T. Mayhall and Tuomo Heikkinin. These are the proceedings of the meeting held in Oulu, Finland, in August of 1998. This handsome volume (492 pages) contains 58 papers organized into sections on dental anthropology, dental evolution, ontogeny, technology, and morphological integration within the dental and craniofacial complex.

Price of the book has been **reduced** to US$50 and the book with the companion CD is US$55. Shipping is extra. These items can be ordered from:

Dr. John T. Mayhall
Oral Anatomy, Faculty of Dentistry
University of Toronto
john.mayhall@utoronto.ca

The similarity in titles of the past two volumes from the Dental Morphology meetings is intentional. John Mayhall suggested in 1998 that future volumes have comparable titles so their origin could be more readily recognized. The thought is that, if the titles are comparable, their soure and serial nature would be more obvious, and papers in these volumes would be cited more often.



Copies of the hard-bound volume of peer-reviewed papers from the **12th International Symposium on Dental Morphology** are available for purchase, along with a CD containing a facsimile of the volume in PDF format. The book (350 pages) contains 30 chapters arranged into six sections covering a broad range of dental research topics. Prices per copy are:

Volume:
£28.00 plus £3.50 postage in UK, or
plus £4.00 in Europe, or
plus £7.50 to other destinations
Compact Disk:
£8.00 plus £1.50 to all destinations.

Note that the CD can be purchased separately. Payment needs to be in English pounds, either by bank draft or credit card. To place an order and for further information, contact:

Mrs. Helen M. Owen
Oral Health & Development
School of Clinical Dentistry
Claremont Crescent
Sheffield S10 2TA U.K.
Tel 0114 271 7885
Fax 0114 271 7843
h.m.owen@sheffield.ac.uk

NOTICE TO CONTRIBUTORS

Dental Anthropology publishes research articles, book reviews, announcements and notes and comments relevant to the membership. 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. 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.

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 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 than can be printed at high resolution (600 dpi or higher). Most common file formats (Windows or Macintosh) are acceptable; check with the Editor if there is a question. The journal does not support color illustrations. 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 common before the date. Examples are (Black, 2000; Black and White, 2001; White et al., 2002). The list of authors is truncated and the Lating 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 References Cited section at the end of the manuscript.

Diskette Submission. Electronic submission *in addition to* 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 paper in electronic format, not interim versions. Files can be submitted on a 3.5″ diskette or a 100-megabyte Iomega Zip disk, 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 EPS format (with preview), or check with the Editor before submitting other file types. Be certain to label the disk with your name, file format, and file names.

Dental Anthropology

Volume 15, Numbers 2 and 3, 2002

Original Articles

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Dental Anthropology Association News and Events