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LOSS OF LINGUAL ENAMEL IN LOWER INCISORS OF PAPIONINI

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INTRODUCTION

The reduction or even the absence of lingual enamel in *Papio* was first observed by Noble (1969). Noble (1969) noted that the lingual aspect of the lower incisors of *Papio* appears to be incompletely covered by enamel and that the enamel was very thin. Later, Delson (1975) described the anterior dentition of papionins to be most distinctive, in that the lower incisors are characterized by the apparent lack of enamel on the lingual surfaces, effectively producing a self-sharpening, nearly rodent-like chisel edge on these teeth (Szalay and Delson, 1979:333). However, Swindler (1976:138) in a study of the lower incisors of *Papio*, *Cercocebus*, *Macaca*, and *Theropithecus* stated, "in our opinion, their lingual surfaces possess a thin layer of enamel, and therefore we cannot agree with Delson's observations."

Furthermore, Gantt's (1977) histological study of enamel thickness in the anterior dentition of nonhuman primates revealed the presence of lingual enamel in the lower incisors of cercopithecines. Gantt measured the thickness of enamel in 39 incisors from four cercopithecines, including *Papio*, and three colobine genera, and reported the presence of a lingual layer of enamel in the lower incisor of *Papio anubis* and *Macaca nemestrina*.

Shellis and Hiiemae (1986) attempted to resolve this controversy by conducting a histological study of enamel thickness on 20 erupted unworn or slightly worn central lower incisors from five cercopithecine and two colobine genera. They reported that the lower incisors of the colobine monkeys had a substantial layer of enamel on both lingual and labial aspects, while the cercopithecines and papionins had little or no enamel on the lingual aspects. This led Strasser and Delson (1987) to interpret their findings to document that cercopithecines, especially the papionins, have eliminated the lingual layer of enamel. The suggestion that cercopithecines have "eliminated the lingual layer of enamel" requires a major change in tooth morphogenesis, which has yet to be verified, and would represent a major developmental difference between the Cercopithecinae and the Colobinae.

PURPOSE/METHODS

This investigation was conducted to determine the presence or absence of lingual enamel in the Papionini. Accomplishing this necessitated obtaining unerupted mandibular incisors, thereby eliminating any artifact due to wear or fracturing of the enamel from erupted teeth. Lower jaws were obtained from *Papio anubis* (N=2), *Macaca mulatta* (N=5), *Macaca nemestrina* (N=3), and *Macaca fascicularis* (N=2). Both central and lateral mandibular incisors were extracted and soft tissues removed.

RESULTS

Thin section analysis (Gantt, 1986) and Scanning Electron Microscope analysis (Fig. 1) demonstrate the lack of lingual enamel in these primate species. Analysis of all unerupted incisors revealed an absence of lingual enamel as is clearly evident in Fig.1. These data definitely support the Strasser and Delson (1987) conclusions on the significance of the lingual enamel in the Papionini. This finding has important implications for primate ontogeny and phylogeny. This absence represents a major change in amelogenesis, resulting in the loss of lingual enamel in the lower incisors, while the upper incisors retain a thin layer of lingual enamel. A detailed study of enamel thickness in the anterior

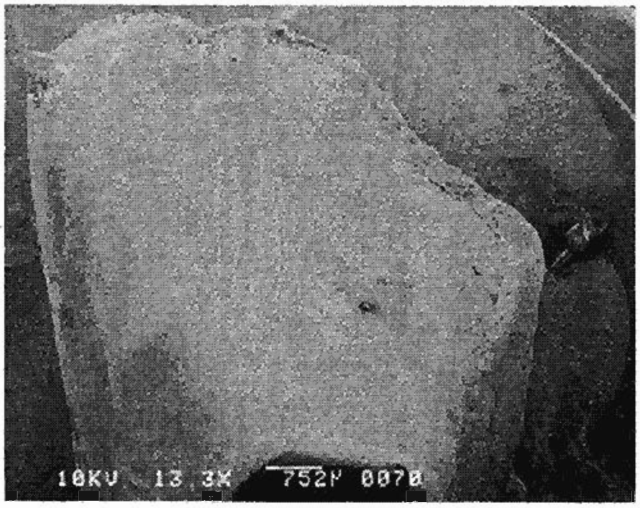

Fig. 1. Mandibular right lateral incisor of *Papio anubis*, age 18 months.

dentition of the Cercopithecidae is presently underway and will elucidate in more detail differences among the subfamilies, Cercopithecinae and Colobinae.

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DENTAL HEALTH AND DIET OF TWO PREHISTORIC POPULATIONS FROM CHILE'S SEMIARID NORTH

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ABSTRACT This investigation examines dental health and diet of two prehistoric populations from Chile's semiarid north. Trace element and dental paleopathological analyses have been conducted on skeletal remains of hunter-gatherers of the Archaic period (n = 99, ca. 1,800 BC) and agriculturalists of the Diaguita period (n = 82, 1,000-1,500 AD). Archaeological and historical evidence indicates that the Diaguita diet primarily incorporated cultivated and wild plants, but also included pastoralism and marine resources. By contrast, the subsistence of Archaic peoples was primarily based on marine resources. Concentration values of the elements strontium and barium (mean log ratio values for Archaic = -0.7985, n=38; for Diaguita = -0.5475, n= 53) support the archaeological evidence for subsistence mode, and thus for diet, of both populations. These concentrations fall within the ranges determined for various archaeological New World populations with similar subsistence and dietary patterns.

Based on the differences in subsistence and diet, the variations in dental health between the two populations were investigated. The analysis to date has revealed that both populations suffered from infectious (antemortem tooth loss, abscesses, caries, alveolar recession), degenerative (calculus deposition), and developmental (enamel hypoplasia) dental pathologies. The differences in frequencies of some of the infection processes are statistically significant between the two populations ($p < 0.05$), but overall do not seem to demonstrate, as many other studies have (Larsen, 1984; Schmucker, 1985; Murphy, 1993), a sharp decline in dental health from the hunter-gatherer population.

INTRODUCTION

This investigation examines the impact on health resulting from the transition to and adoption of farming in the semiarid north of Chile. A large body of paleopathological evidence (Cohen, 1977, 1989; Cohen and Armelagos, 1984; Larsen, 1984; Schmucker, 1985; Swedlund and Armelagos, 1990; Stuart-Macadam, 1989; Murphy, 1993) supports an accepted model for biological adaptation which states that the adoption of farming and concomitant sedentism, despite a positive effect these may have on population growth, may in fact have negative effects on health and life expectancy.

In general, sedentary agricultural populations show an increase in frequencies of infections (as evidenced from periosteal reactions on bone) and anemia indicating diets nutritionally deficient (as indicated by porotic hyperostosis and *cribra orbitalia*) when compared to the relatively more mobile gatherer-hunter populations. This increase results from the synergism between infection and malnutrition (deficiencies from blight, drought, and the reliance on few crops which may be deficient in essential nutrients) and increase in sedentism and population size. Increase in population size, density and unsanitary conditions increase the possibility of epidemic and chronic disease transmission.

Specifically, a clear association exists between increased use of agricultural foods, which contain high levels of carbohydrates and which promote growth of cariogenic bacteria, and high amounts of dental infections such as caries and abscesses (Turner, 1978; Larsen, 1983; Schmucker, 1985; Hillson, 1986). Archaeologists at the Museo Arqueologico of La Serena, La Saena, Chile, and Rosado would like to see if a similar situation exists for the sedentary, agricultural populations of the semiarid north with regards to dental health.

The model for biological adaptation is being applied to the paleopathology research. The general hypothesis being tested states that poorer health status and more nutritional problems are associated with agricultural populations of the semiarid north than with Archaic period populations. This communication summarizes the initial results of the trace element and dental paleopathological analysis for two northern Chile coastal populations of Coquimbo Bay: Archaic of El Cerrito-La Herradura and the Diaguita of La Serena-Penuelas.

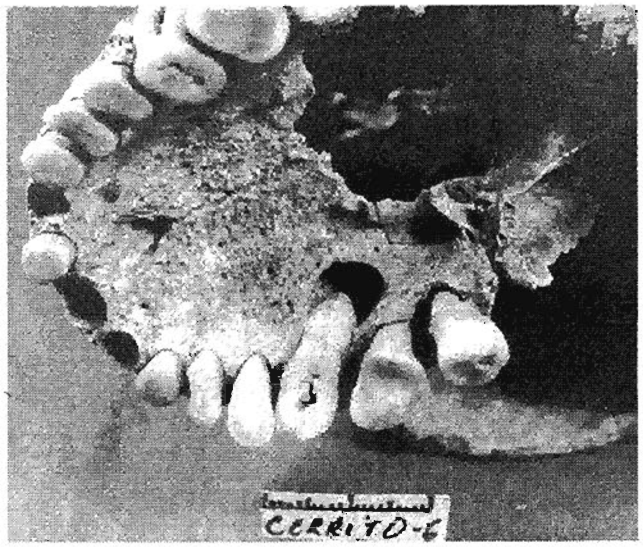

Fig. 1. Archaic adult male maxillary dentition from the site of El Cerrito-La Herradura, Coquimbo Bay, Chile. The individual exhibits dental wear and an abscess on the right first molar. (Photograph by M. Rosado)

MATERIALS

The Museo Arqueologico authorities made available for analysis two coastal skeletal samples of individuals who inhabited the area of Coquimbo Bay in the semiarid north. Ninety-nine individuals (31 adult females, 28 adult males, and 41 adults and subadults of unknown sex) are hunter-gatherers and represent the Archaic period with a radiocarbon date of 3,780±550 BP (Kuzmanic, 1986; Castillo, 1991). Eighty-two individuals (29 adult females, 24 adult males, and 29 adults and subadults of unknown sex) represent the Diaguita period. Various radiocarbon assays place the Diaguita populations between 500 and 1,000 BP (Ampuero, 1975, 1989; Biskupovic, 1982-85). The dentition of an Archaic male is shown in Fig. 1; the dentition of a Diaguita male, in Fig. 2.

Shellfish, sea lion, and camelid bones found in burials and hearths and associated with human skeletons strongly indicate that these animals were consumed by Diaguita populations. The evidence of consumption of cultivated plants is provided by the chronicles of the first Europeans in the region of the semiarid north. They clearly described the Indians consuming and storing potatoes, maize, quince, beans, and squash (Bibar, [1555]1966; Ampuero, 1989). Archaic period hunter-gatherers seem to have consumed mostly marine resources, but also included some terrestrial mammals and birds. The evidence for this comes from the bones of fish, sea lion, chinchilla, and camelid, and the shells of various mollusks (e.g., *Conchalepas, Mytilus, Mesodesma*) also found in burials and hearths and also associated with human skeletons (Kuzmanic, 1986; Hidalgo, 1989; Castillo, 1991).

If Archaic period peoples consumed plants, the types are not clear yet. That marine and terrestrial plants were incorporated into the diet is likely. The grinding of these is suggested by the presence of mortars found in a cemetery of Archaic period peoples (Kuzmanic, 1986; Castillo, 1991).

Fig. 2. Adult Diaguita male maxillary dentition from the site of Penuelas 21, La Serena, Coquimbo Bay, Chile. The individual exhibits dental wear and caries on the left first molar. (Photograph by M. Rosado)

METHODS

Determination of Age and Sex

Age at death within 10 year ranges was ascertained using gross osteological markers observed on the long bones, pubis symphysis, sacrum, ribs, auricular surface of ilium, cranium, and teeth (Steele and Bramblett, 1988; Iscan and Kennedy, 1989; Rose *et al.*, 1991; White, 1991). The category "adult" (trace element analysis) included individuals with the third molar present (18 years and older). "Subadults" (dental wear analysis) consisted of individuals 0-17 years of age. Sex (male, female, and unknown categories) was determined from gross osteological markers on the pelvis and cranium (Steele and Bramblett, 1988; White, 1991). Individuals were represented by most of the bones diagnostic of age and sex, as preservation of the skeletal remains ranged from excellent to good (entire skeleton represented to most parts of cranium and post cranium represented, respectively).

Trace Element Analysis

Ninety-one adults (Archaic, n= 38; Diaguita, n= 53), represented by adult cortical bone, either femur or tibia, were analyzed for trace elements (Table 1). Small pieces (0.25 in. by 0.25 in. minimum dimension) of bone were cut and sent to the Laboratory for Archaeological Chemistry, University of Wisconsin. At the laboratory, the bone pieces were analyzed by Dr. James Burton and colleagues according to procedures described by Burton and Price (1990a,b). Burton and colleagues determined concentration values (expressed in micrograms per gram of bone ash, parts per million) of the elements strontium and barium. Because the investigations on trace elements cited above provide values for trace elements in logarithmic form, the values determined in this study have been converted to logarithmic form for comparison. The statistical calculations used to compare concentrations between the two populations use the logarithmic values. The z test, inference about means, was used to determine if statistically significant differences in concentrations exist between the mean logarithm of Barium (mean log [Ba]) and the mean logarithm of strontium (mean log [Sr]) of the Archaic and Diaguita samples.

Dental Paleopathology

The skeletal remains were examined visually for the manifestation of non-specific dental paleopathological markers. The following were observed: enamel hypoplasia, antemortem tooth loss (AMTL), caries, abscesses, calculus deposition, and alveolar recession and resorption (AR). In addition, a comparative analysis of dental wear was accomplished. Scales used for scoring degree of pathology and wear include those of Hillson (1979) (caries and calculus severity), Brothwell (1981), Schmucker (1985), and Bass (1987) (abscess location, antemortem tooth loss, alveolar recession/resorption, enamel hypoplasia). Occlusal surface wear was assessed for the deciduous and the permanent posterior dentition using Schmucker's (1985) scoring technique. Molnar's technique was also used as an initial general assessment of wear. However, the ordinal scale (that approaches an interval scale) used by Schmucker was preferred because: 1) it scores all teeth (single and multi-cusped); 2) it is specific for very precise recognition of wear in each tooth category; and 3) the wear severity grades described for each category (grades 1-8) are gradual.

The z test of proportions was used to determine whether the differences in frequencies of dental pathology observed between the Archaic and Diaguita samples are statistically significant. The Mann Whitney U test was used to determine if statistically significant differences exist between the mean dental wear observed in the two populations. Schmucker's wear scale approximates an interval scale. Therefore, the Mann-Whitney U test can be accomplished.

TABLE 1. Mean log [Ba/Sr][1] by sample

	n	mean log	Std. Dev.
Archaic	38	-0.7985	+0.0743
Diaguita	53	-0.5475	+0.2064

z test (estimator of the mean of Diaguita minus the mean of the Archaic) = 8.120
One tailed probability = 0.000 ($p<0.005$)

[1]Mean logarithm of the concentration of barium to strontium ratio. n is sample size and includes males, females, and unknown sex. Std. Dev. is standard deviation.

RESULTS

Trace Elements

The archaeological and historical evidence for subsistence that indicates differences between the two populations in foods consumed is supported by trace element analysis. As demonstrated by Burton and Price (1990a,b), marine organisms have lower barium concentrations and lower barium to strontium ratios than terrestrial organisms have. The low barium concentrations and low barium to strontium ratio of marine organisms produce correspondingly low barium and low barium to strontium ratios in the humans that consume relatively higher quantities of marine organisms. The mean log ratio concentration values of the elements barium and strontium with z test (inferences about means) are provided in Table 1. Note the statistically significant ($p<0.05$) relatively low mean log [Ba/Sr] value for the Archaic sample.

According to J. Burton (personal communication), this indicates significantly more marine resources in the diet of the Archaic than the Diaguita. The mean logarithm of barium concentration (mean log [Ba]) and strontium concentration (mean log [Sr]) (2.1045 and 2.6414, respectively) for the Diaguita sample is within the range for the log [Ba] and [Sr] (1.7000-2.7000 and 2.5000-3.5000, respectively) identified by Burton and Price (1990a) for human populations with terrestrial diets. The mean log [Ba] of the Archaic sample of 1.9407 is slightly higher than the range of 0.7000 - 1.4000 determined by Burton and Price (1990a) for populations with predominantly marine diets. The mean log [Sr] of 2.7378 is within the upper limit of the range (2.4000-2.7000) identified for human populations with predominately marine diets. These values support the archaeological and historical evidence for diet. They indicate that Archaic period peoples relied primarily on marine resources and Diaguita period peoples relied primarily on terrestrial resources in a mixed agricultural-pastoral-maritime economy.

In order for trace elements to be useful in diet reconstruction of archaeological samples, the amount of these detected in the bones must reflect their antemortem concentration and not the amount resulting from, for example, soil contamination. Sandford (1993) provides extensive discussions on the factors which have an impact on diagenetic exchange. These include geochemical, biochemical, and organic processes that affect bone postmortem, thus altering the concentration of the elements. All human remains from archaeological contexts appear to have been exposed to some diagenetic alteration. Thus, investigators should implement strategies, according to Sandford (1993), that diagnose and delineate the mechanisms of diagenesis at any one particular site. These strategies include analysis of soil chemistry from burial and non-burial sites, comparisons between trace element concentrations in the soil and the bones buried therein, comparisons among different anatomical parts, and comparisons between human and animal bones within the same context.

The skeletal remains housed at the Museo Arqueologico will provide the opportunity to apply these strategies, and the concentration values provided in this study will be used as a basis for comparison. For now, the concentration values are provided for documentation purposes and they seem to support the historical and archaeological evidence for diets of the two samples analyzed in this investigation. However, diagenetic exchange has to be considered in future analyses.

Dental Paleopathology

Rosado conducted dental paleopathological analyses using non-specific stress markers and applied the model for biological adaptation. The hypothesis tested predicts that overall dental health declines from the hunting-gathering Archaic people to that of the agricultural Diaguita. Table 2 and Fig. 3 summarize the frequencies of the dental pathologies observed in the permanent dentitions (males and females pooled).

Caries

The caries observed in both samples most often occur on the occlusal surface. Most reach a severity whereby the enamel is destroyed and the dentine is left exposed. In many cases the infection followed a course of progressive destruction until the alveolar bone tissue was compromised by the formation of abscesses.

The Diaguita sample has a higher frequency of caries than that observed in the Archaic sample (more than twice the amount) (Table 2, Fig. 3). These results seem consistent with a diet containing high levels of carbohydrates, such as that of the agricultural Diaguita.

TABLE 2. Frequencies of dental pathologies

	Caries		Abscess		AMTL		Calculus		AR		Enamel Hypoplasia	
	+/n	%	+/n	%	+/n	%	+/n	%	+/n	%	+/n	%
Archaic	22/625	0.4	113/958	12.0	113/923	14.4	403/596	68.0	33/814	4.0	4/46	8.7
Diaguita	87/786	11.3	46/1073	4.0	167/1062	15.7	335/680	49.0	77/834	9.0	10/55	18.2
	z test=5.280	p=0.000	z test=6.290	p=0.000	z test=0.808	p=0.209	z test=6.628	p=0.000	z test=4.245	p=0.000	z test=1.320	p=0.0934

Frequencies are based on tooth or alveolar space counts in the permanent dentition. AMTL is ante-mortem tooth loss. AR is alveolar recession for which + represents severe. + is present. n is sample size. % is the percentage of +/n. z test is the test of proportions (estimator of p1-p2). p is the two-tailed probability. 1 is Diaguita. 2 is Archaic.

TABLE 3. Wear grade (mean dentine exposure) on maxillary molars.

Age, sex	Teeth	Archaic n	Archaic Mean	Diaguita n	Diaguita Mean
0-9 years	m1	3	4.0	7	1.0
	m2	3	2.0	6	1.0
10-17 years	M3				
	M2	3	3.6	3	1.6
	M1	6	3.6	4	3.0
18-29 years, males	M3	8	2.5	2	1.7
	M2	12	3.5	6	2.6
	M1	12	5.5	7	3.4
18-29 years,	M3	4	1.5	2	1.0
	M2	4	3.2	4	1.7
	M1	6	4.5	6	2.8
30-39 years, males	M3	2	3.0	1	2.0
	M2	4	3.5	8	3.5
	M1	4	5.0	8	4.1
30-39 years,	M3	2	4.0	1	2.0
	M2	2	6.0	3	3.0
	M1	6	5.8	2	4.3
40+ years, males	M3	9	4.3	2	1.0
	M2	11	5.7	8	4.3
	M1	13	7.0	9	5.5
40+ years, females	M3	3	7.3	4	2.5
	M2	9	5.3	9	3.0
	M1	12	6.9	8	4.5

n is number of individuals in the sample. m1 is deciduous first molar. m2 is deciduous second molar. M1 is permanent first molar. M2 is permanent second molar. M3 is permanent third molar. Empty cells indicate lack of data. Wear grades are according to Schmucker (1985).

TABLE 4. Dental wear P1-M1 in the maxilla.

Age, sex	n	p value	Greater wear (>rank sum)
0-9 years	19	0.1226	no difference
10-17 years	24	0.1562	no difference
18-29 years, males	75	0.0473	Archaic
18-29 years, females	48	0.0473	Archaic
30-39 years, males	49	0.4173	no difference
30-39 years, females	29	0.0301	Archaic
40+ years, males	99	0.4773	Archaic
40+ years, females	90	0.0061	Archaic

n is number of individuals in the sample. P1-M3 is permanent first premolar to third molar. Analysis is based on mean dental wear values summed (ranked) over P1-M3. p is probability. the p value is the one-tailed probability. Dental wear was evaluated after Schmucker (1985).

Abscess

The Archaic sample has a frequency of abscesses (Table 2, Fig. 3) that is three times that observed in the Diaguita sample. Given the extent of the wear observed in the Archaic sample in which dentine and pulp chambers start to be exposed at a relatively younger age (Tables 3 and 4, Fig. 3), the abscesses observed may be the result of direct infection by bacteria. These results are consistent with those of other researchers (Schmucker, 1985), which determined that the formation of abscesses increases as dental wear becomes severe. Enamel wear exposes the relatively softer dentine to bacterial penetration and, when caries are formed, they proceed to the pulp comparatively more rapidly. This can occur even if the diet is not high in carbohydrates, as is the case for the Archaic sample in which marine resources, which are gritty and abrasive, and not resources high in carbohydrates, dominate the diet.

Antemortem Tooth Loss (AMTL)

The causes for antemortem tooth loss in both populations appear to lie in the formation of abscesses and calculus deposition of moderate to large size, which promoted gingival irritation and alveolar recession. No statistically significant differences between the two populations exist in the proportion of teeth lost antemortem, when the comparison is done for all tooth categories considered together (I1-M3) (Table 2). However, the Diaguita population's posterior teeth (P1-M3) displayed greater antemortem tooth loss (139 posterior affected out of 431 total posterior teeth = 32%) than the Archaic population (88 posterior affected out of 457 total posterior teeth= 19%). This difference is statistically significant ($p<0.05$, z test of proportions = 0.029) (Table 2). Possibly, a relationship exists between the relatively higher frequency of caries (mostly on the occlusal surface of the molars) in the Diaguita and the relatively higher frequency of antemortem tooth loss of posterior teeth. Caries promote infection of the dentine and pulp region of the tooth which may result in the formation of an abscess with subsequent evulsion.

Calculus

The Archaic population had a greater frequency of teeth with calculus deposition of moderate size than the Diaguita (Table 2, Fig. 3). Possibly, the greater emphasis of the Archaic than the Diaguita on maritime resources (relatively higher in calcium content from sand and shellfish) may have promoted calculus deposition. Some scientific evidence supports the role of calcium in promoting the formation of calculus (Stanton, 1969).

Alveolar Recession-Absorption (AR)

In contrast, the Diaguita population had a relatively greater frequency of teeth and alveolar spaces affected by severe recession-resorption (Table 2, Fig. 3). In both populations alveolar recession-resorption seems strongly to have had its origins in periodontal disease, other infectious processes, that include caries and abscessing, or a combination of these processes. In this case, the severity of alveolar recession and resorption in the Diaguita population suggests these people were more affected by periodontal disease than the Archaic population was. Possibly, the increase in the distance between the cemento-enamel junction and alveolar bone observed in both populations was the result of tooth tilting and continuous tooth eruption as a response to excessive dental wear. This possibility needs to be taken into consideration in future dental analyses of the Diaguita and Archaic populations.

Enamel Hypoplasia

Of 46 Archaic individuals with available dentitions, four were affected by enamel hypoplasia. Out of 55 Diaguita individuals with available dentitions, ten were affected by enamel hypoplasia (Table 2, Fig. 3). In the Archaic sample, all individuals affected were male and in the Diaguita sample five were female; three were male; and two were of unknown sex.

Of 625 individual teeth examined in the Archaic period population, 2.4% (15 teeth representing four individuals) were affected by enamel hypoplasia. Of 768 teeth examined in the Diaguita population, 7.0% (52 teeth representing ten individuals) were affected. By using Brothwell's scheme it was determined that most of the teeth observed were affected by "slight" severity of enamel hypoplasia. The differences observed between the two populations in the frequency of persons affected is not statistically significant. However, the presence of the enamel defect does indicate that the persons affected suffered some type of growth disruptive stress during childhood.

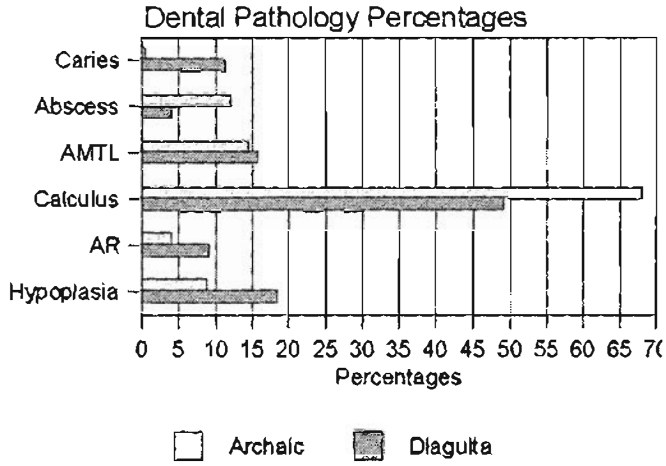

Fig. 3. Comparative frequencies of dental pathologies in the Archaic and Diaguita. Table 2 has the percentages. AMTL is antemortem tooth loss. AR is alveolar recession.

Dental Wear

The dental system of both samples indicates excessive use throughout life, as observed from the severe wear. However, the greatest mean dental wear is found in the Archaic population for the maxilla (Tables 3, 4; Figs. 4, 5). Table 4 provides summary results of the Mann-Whitney calculations applied to mean dentine exposure values (mean dental wear) across P1-M3 for the maxilla. The results are separated by sample, sex, and age. The mandibular teeth yielded the same results regarding the sample with the greatest wear grade. Using Schmucker's (1985) dental wear scheme for the molar teeth, the Archaic sample reaches wear grades six and seven (entire tooth is surrounded by enamel and the roots are functioning at the occlusal level, respectively) by age forty (Table 3). In contrast, the

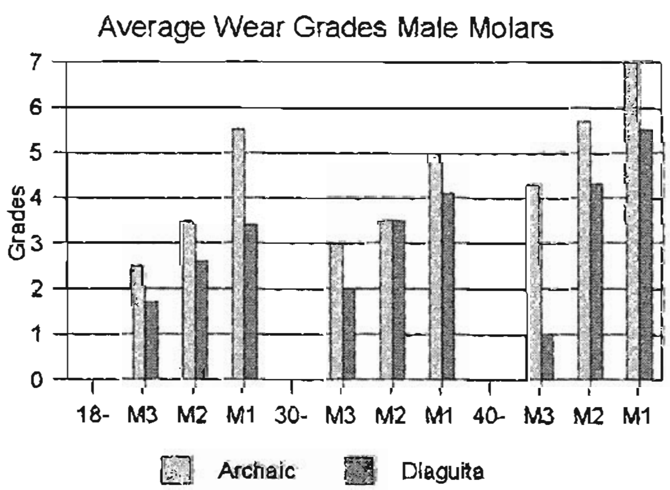

Fig. 4. Comparative mean grades (mean dentin exposure) of adult male molars for ten-year age spans (after Schmucker, 1985). 18- is the age interval 18-29. 30- is the age interval 30-39. 40- is individuals older than 40. Table 3 has the data.

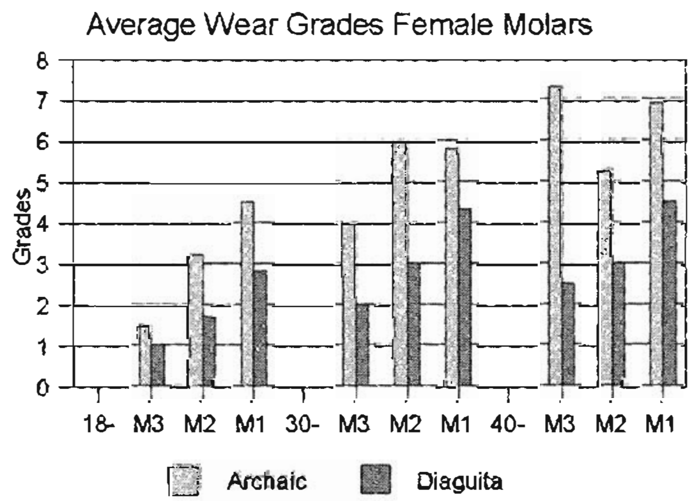

Fig. 5. Comparative mean grades (mean dentin exposure) of adult female molars for ten-year age spans (after Schmucker, 1985). 18-is the age interval 18-29. 30- is the age interval 30 to 39. 40- is individuals older than 40. Table 3 has the data.

Diaguita sample reaches wear grades four and five (the cusp pattern is obliterated and large dentine patches are visible, respectively). This difference is statistically significant in ten adult categories out of sixteen analyzed for both maxilla (Table 4) and mandible. These results are consistent with those of Schmucker (1985), whose California hunter-gatherer populations also had significantly more wear than the agricultural ones.

The wear observed in both populations is consistent with a diet containing gritty-abrasive components that could be obtained from sand and/or from the stone-grinding of foods. This would be expected, especially for the Archaic population whose members relied more heavily than the Diaguita on maritime resources. These marine resources have a high level of gritty components.

CONCLUSIONS

Of the eight non-specific stress markers used to estimate the dental health status in the Archaic and Diaguita populations in this study, four had frequencies that were significantly different between the two. These were dental caries, dental abscesses, dental calculus, and alveolar recession/resorption. The expectation was, however, as previous studies on health and agriculture have shown (Larsen, 1984; Schmucker, 1985; Murphy 1993), that relatively greater frequencies of all markers would be found entirely in the agricultural Diaguita population. However, this was not the case.

The Diaguita population has greater frequencies of dental caries and alveolar recession than the Archaic population. The Archaic population has greater frequencies of calculus deposition and abscesses than the Diaguita population. The higher amounts of carbohydrates in the diet of the Diaguita population than in the Archaic very likely promoted more caries formation and periodontal disease (contributing to the alveolar recession) than in the Archaic. Yet, alveolar recession may also have its origins in continuous tooth eruption. However, the numbers reported for caries in this study are still low compared to other published reports for agriculturalists (e.g., Murphy, 1993).

The severe dental wear in the Archaic may have promoted the relatively higher amount of abscess formation. The comparatively higher dental calculus frequencies are probably linked to calcium levels in a diet that emphasized maritime resources. The results of this study suggest that the differences in frequencies of dental pathology markers observed between the two populations are the result of day-to-day use and wear rather than solely due to diet. Also, if pathological effects did result from a diet high in carbohydrates, as that of the Diaguita, or from a diet which promoted great wear, as that of the Archaic, these were very likely quickly counteracted by high levels of fluorides found in marine resources and sea water.

Much work still needs to be done in terms of testing hypotheses about biological adaptation to environments, such as Chile's semiarid north, and diets of not only coastal populations but interior valley ones as well. Various sites are currently being excavated (personal communication with Museo Arqueologico authorities) and are yielding many skeletal remains and additional evidence for subsistence and diet from different time periods. The information presented here will be used as a baseline to guide future paleopathological studies.

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A UNILATERAL CONNATE INCISOR IN A CA. 2,000 YEAR OLD MANDIBLE FROM THE MIDDLE COLUMBIA RIVER PLATEAU

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INTRODUCTION

Examination of skeletal material from a Late Archaic cemetery site, Wildcat Canyon (35GM9), in the Middle Columbia River Plateau, Oregon, revealed the presence of a unilateral connate incisor in an Amerindian child's mandible (Fig. 1). This was the only case of connate teeth in this collection which represents at least 75 individuals. The individual derives from the main cemetery at the site dating between 100 BC and 1 AD (Dumond and Minor, 1983).

TRAIT DISCUSSION

Connate teeth, or more commonly referred to in the clinical literature as double teeth (Miles, 1954; Brook and Winter, 1970; Yenn *et al.*, 1987), include both dental fusion and gemination. Dental fusion is defined as the partial (at the root or crown) or complete union, during development, of two or more adjacent teeth (Pindborg, 1970; Duncan and Crawford, 1996). Gemination is the complete or partial division, during development, of a single tooth crown (Pindborg, 1970; Duncan and Crawford, 1996). Dental fusion can occur between two normal teeth and between a normal tooth and a supernumerary tooth, although the latter is difficult to distinguish from gemination (Nik-Hussein, 1992).

An attempt at distinguishing between dental fusion and gemination can be made in a number of ways, although none of the methods are foolproof. Fused teeth result in a diminished number of total teeth in the dentition, when fusion is between two normal teeth and the fused tooth pair is counted as one tooth. Gemination results in the normal

Fig. 1. Dental fusion of the deciduous mandibular right central and lateral incisors on a five-year old child from the Columbia River Plateau. The dentition of the individual is complete, but the maxillary deciduous left central incisor and the mandibular deciduous left canine could not be placed in the dental arcade because of faulty reconstruction.

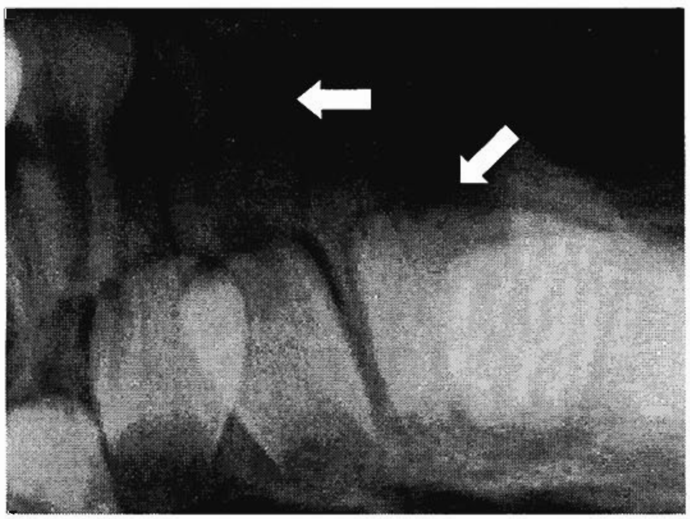

Fig. 2. X-ray of the anterior mandible of a five-year old child from the Columbia River Plateau. The arrow on the left indicates the complete fusion of the deciduous right central and lateral incisors. The arrow on the right points to the possible presence of a geminated permanent left central incisor.

complement of teeth when the geminated tooth is counted as one tooth. However, this result is also achieved when fusion occurs between a normal tooth and a supernumerary. In addition, the presence of hypodontia with connate incisors can also confuse the distinction between gemination and fusion (Brook and Winter, 1970). Geminated teeth can also be distinguished from fused teeth on the basis that geminated teeth are often mirror images of one another (Kelly, 1978).

Connate teeth occur most often in the anterior mandibular deciduous dentition (Brook and Winter, 1970; Kelly, 1978), but are also common in the permanent teeth, particularly between third molars and supernumerary teeth. Incidences for their occurrence in deciduous teeth range from 0.14 to 5.00% with no sex predilection, and unilateral expression is more common than bilateral expression (Brook and Winter, 1970). Connate teeth are also common in non-human mammals (Miles and Grigson, 1990), including many primate species (Miles and Grigson, 1990; Winkler and Swindler, 1993; Lukacs, 1998 pers. comm.).

Little is known about the worldwide distribution of this anomaly, but a strong racial component is suspected (O'Reilly, 1990). Duncan and Helpin (1987) report that Amerindians, Asians, and Mexicans exhibit the highest frequency of the trait. This is supported by various researchers including Brown (1968), who found a high incidence in Crow Indian school children (1.20%), by Saito (1959) and Niswander and Sujaku (1963), who report a 5.00% and 2.50% incidence, respectively, in living Japanese, and by Yamamoto (1989), who reports an incidence of 4.80% in Edo period Japanese. Bazan (1983), Brook and Winter (1970), Buenviaje and Rapp (1984), Järvinen *et al.* (1980), and Magnússon (1984) indicate an incidence in Caucasian populations at less than 1.00%. Ruprecht *et al.* (1985) found similar results in Saudi dental patients with an incidence at 0.40%.

Although cases of dental fusion and gemination are asymptomatic (Lamego Velasco *et al.*, 1997), dental fusion can result in a number of dental difficulties including tooth number reduction in the permanent successors (Ravn, 1971; Gellin, 1984), increased susceptibility to subgingival bacterial plaque (Brook and Winter, 1970; Mader, 1979; Lamego Velasco *et al.*, 1997), delayed eruption of the permanent teeth (Brook and Winter, 1970; Peretz and Brezniak, 1992), aplasia or malformation of the permanent successors (Peretz and Brezniak, 1992), and dental impaction.

SPECIMEN DESCRIPTION

Only a handful of archaeological examples of dental fusion or connate teeth have been reported (Sciulli, 1977, 1998; Ortner and Putschar, 1981; Stevenson, 1985; Yamamoto, 1989; Drusini and Swindler, 1994). In the case reported here, connation occurs between the lower deciduous right central and lateral incisors of a child of approximately five years of age at death (Fig. 1). Fusion is indicated by the lower than normal complement of teeth and the retention of morphological similarity of the lower right central deciduous incisor with its antimere. Inspection of the crown and the radiograph of the fused tooth (Fig. 2) reveals that the fusion is complete and the two teeth share a common pulp chamber. The lower right central incisor is rotated approximately forty-five degrees with the mesial end of the tooth rotated lingually. No rotation of the lower left central incisor was observed. Figure 2 also reveals what appears to be a geminated unerupted central left permanent incisor, roughly twice the size of its antimere, and otherwise normal permanent successors.

The dentition exhibits a stepped appearance of the occlusal plane due to relatively heavier wear in the incisor region over the canine-molar region. Both the upper and lower anterior dentition also exhibits a significant degree of alveolar resorption due to periodontal disease. Calculus deposits are also noted in the groove between the two fused teeth. Other pathologies noted in the dentition include localized enamel hypoplasia of both deciduous lower canines, which is also known as localized hypoplasia of primary canines or LHPC (Skinner, 1986), and of the deciduous upper right canine.

CONCLUSION

A unilateral connate deciduous incisor in a ca. 2,000 year old Amerindian child's mandible is presented. This case conforms to generalizations about the trait, including a relatively higher incidence in Amerindians, a comparatively more frequent occurrence in anterior mandibular deciduous teeth, and an increased susceptibility to subgingival plaque. The reduced number of teeth indicates dental fusion between the right central and lateral deciduous mandibular incisors.

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PREMOLAR DOUBLE TEETH IN A GROUP OF IRISH ORTHODONTIC REFERRALS

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ABSTRACT This is a report of gemination type premolar double teeth in patients who were referred for orthodontic consultation in the Eastern Health Board, Ireland. Prevalence was low (0.06%) with just three patients presenting with this dental anomaly. The premolar double teeth involving two maxillary and one mandibular premolar are illustrated.

INTRODUCTION

Dental fusion is defined as a condition where two separate tooth buds join together during development and present with the appearance of a bifid crown. Confluence of dentine and/or enamel occurs. Frequently, one root and two root canals occur. Clinically a tooth is missing in the affected quadrant (Levitas, 1965; Hagman, 1988; Morris, 1992). Connation, dichotomy, twinning, and schizdontia are terms that have been used to describe this type of dental anomaly (Smith, 1980). Gemination, another term, is defined as an attempt by a single tooth bud to divide. Partial division is halted before dental development is complete. The result is a single tooth with a bifid crown (Niswander and Sujaku, 1963; Morris, 1992). Generally the tooth has a single root canal and clinically, unlike fusion, no disruption in the normal number of teeth occurs (Levitas, 1965). The presence of a supernumerary bud complicates these definitions. In clinical practice distinguishing between dental fusion and gemination is frequently difficult. (Brook and Winter, 1970; Morris, 1992). Thus, the term "double teeth" has been suggested (Brook and Winter, 1970: 123).

The etiology of double teeth is not known. Racial variation together with familial associations indicate a genetic component (Brook and Winter, 1970), but local factors such as trauma and abnormal eruption of adjacent teeth have been suggested (Morris, 1992). The frequency of double teeth is greater in the primary dentition than in the secondary dentition. Prevalence ranges from 0.1% to 0.9% in the primary dentition and 0.1% to 0.2% in the secondary dentition (Levitas, 1965; Brook and Winter, 1970; Gellin, 1984). No significant gender bias has been reported (Gellin, 1984). Double teeth occur most commonly in the incisor and canine regions (Brook and Winter, 1970; Duncan and Helpin, 1987). Reports of double teeth in the premolar region are few (Brook and Winter, 1970). Prevalence of double teeth is also rare in the molar region, but pathological union of cementum in adults may occur giving rise to late onset dental concrescence (Levitas, 1965; Brook and Winter, 1970).

Racial variation exists with increased prevalence reported in Japanese (Smith, 1980; Hagman, 1988) and North American Indian populations (Duncan and Helpin, 1987). In cases where double teeth present in the primary dentition the probability of anomalies in the secondary dentition is increased (Gellin, 1984). Aplasia of the permanent incisor has been reported in up to 18.0% of cases, where fusion of a corresponding primary incisor was found. (Hagman, 1988). Should fusion occur in the primary lateral incisor-canine area, the incidence of a missing permanent incisor is even greater than 18.0%, with up to 50.0% of cases affected (Hagman, 1988).

Fig. 1. Case 1, a geminated type double tooth in the maxillary first premolar. Extensive enamel hypoplasia is evident.

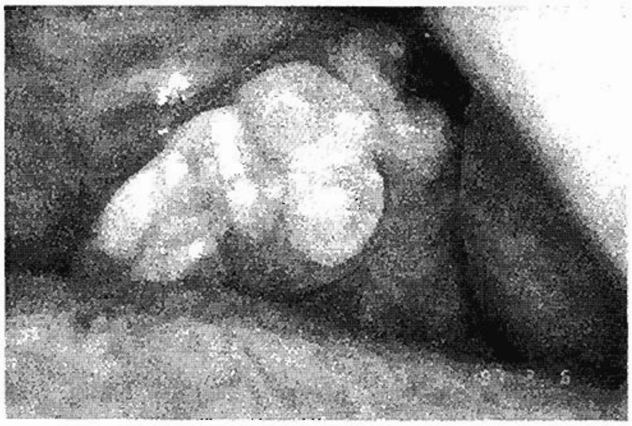

Fig. 2. Case 2, a gemination type double tooth in the mandibular second premolar. The enamel is normal throughout.

Fig. 3. Case 3, a gemination type double tooth in the mandibular first premolar. The dimensions of the two sections of this premolar are more comparable than those in either Case 1 or Case 2. The enamel is normal.

REPORT OF THE CASES

In an orthodontic screening programme in the Eastern Health Board, Ireland, involving 5,230 patients, five presented with gemination-type double teeth. Three patients presented with this dental anomaly in the premolar area. The two remaining patients had geminations involving respectively, a permanent maxillary and mandibular incisor, and are not described.

An isolated double tooth was found in the premolar region in Case 1, Case 2, and Case 3 (Figs. 1,2,3). The three patients were female and Caucasian. The number of teeth in all four quadrants was not disrupted suggesting gemination-type double premolar teeth. Different premolars were affected: maxillary first in Case 1, mandibular second in Case 2, and mandibular first in Case 3.

The patients were asymptomatic. They were in good dental health with only Case 3 presenting with minor disturbance to the occlusion. In Case 1 the conventional form of a first premolar could be observed, but extensive occlusal enamel hypoplasia (Fig. 1) with some carious areas could be seen. The enamel hypoplasia extended on to the facial aspect of the well formed buccal cusp. The enamel of the most palatal area of the crown was normal. The aetiology of the enamel hypoplasia was unknown but was considered to be local in origin as the enamel of the remaining dentition was normal. In Cases 2 and 3 the enamel was normal throughout.

In all three patients no other dental anomalies were noted. The remaining dentition was normal in tooth number, morphology, and form. A family history of geminations or anomalies in the primary dentition could not be ascertained with certainty. No significant dental history, such as trauma to the permanent dentition, was found. Clinical examination of the immediate family members of Case 1 was carried out. No dental anomalies were found.

DISCUSSION

The aetiology of double teeth is still not understood (Brook and Winter, 1970; Smith, 1980). Hereditary and environmental factors have been suggested. Environmental factors such as localized pressure or trauma to the developing tooth bud have been proposed which may give rise to a double tooth formation (Smith, 1980). The hereditary influence is supported by many studies (Moody and Montgomery, 1934; Grahnen and Granath, 1961; Niswander and Sujaku, 1963; Levitas, 1965; Curzon and Curzon, 1967; Hagman, 1985) which have reported a familial predisposition. Hereditary factors are also supported by the racial variations that exist. In Niswander and Sujaku's (1963) study reporting the high incidence of fusion amongst Japanese children in the primary dentition, approximately 50% of these children were offspring of biologically related parents. The mode of inheritance of double teeth is not understood but may be either autosomal recessive or dominant with very little penetrance (Brook and Winter, 1970).

In these three premolar cases a definitive family disposition could not be ascertained with any certainty, but none reported a family history of this dental anomaly. The immediate family members of Case 1 were examined and no dental anomalies were found.

The reported prevalence of double teeth is varied with little data available on their prevalence in the primary dentition (Brook and Winter, 1970; Hagman, 1988). Of the 5,230 referrals examined only five patients presented with double teeth suggesting a prevalence within this orthodontic population of 0.1%, which is similar to reported data on general population groups in studies by Grahnen and Granath (1961) and Boyne (1955). The premolar location of the anomaly was an unexpected finding. Little data could be found on premolar double teeth. In Duncan and Helpin's (1987) review of double teeth no reference was made to premolar teeth. The most common location for double teeth was in the incisor and canine region (Brook and Winter, 1970; Duncan and Helpin, 1987). Instances of premolar double teeth are unusual. Brook and Winter (1970) cited Boucher (1948), who reported a patient with double teeth involving a mandibular canine and premolar. Bennett (1931) reported a second premolar union with a supernumerary tooth while Colyer and Sprawson (1942) reported a premolar double tooth, which was similar to the type of double teeth found in this study. While all three cases in this study were female, no trend was found in relation to premolar tooth or location. First and second premolars presented with this anomaly, in addition to both a mandibular and maxillary location.

SUMMARY AND CONCLUSION

In conclusion, the number of premolar double teeth in patients referred to the Eastern Health Board Regional Orthodontic Department, Ireland, was low. The gemination type double teeth were of little aesthetic or functional significance. This study suggests that the predominance of premolar geminated teeth over incisor geminated teeth may have been due to the concerns of the referring dentist about occlusion rather than aesthetics. Thus, the referrals were made to an orthodontic service. Further study of the Eastern Health Board's general population is necessary to ascertain the exact prevalence of this dental anomaly, in addition to the factors influencing referral by general dental practitioners.

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ANALYSIS OF THE OPTICAL PROPERTIES OF MEDIEVAL ENAMEL

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ABSTRACT The purpose of the study was to investigate the differences in the optical properties of samples of intact, abraded, and reduced enamel. The optical properties of medieval enamel were compared to the results obtained from studies of enamel of contemporary populations in order to investigate the structural changes of enamel due to the effect of diagenesis (destructive changes, which affect interred bone). Reduced enamel (artificially removed superficial layer of the enamel) was used as a comparative sample for the study of abraded enamel.

The dental material was obtained from the medieval cemetery site of Stara Torina located in northern Serbia. Micro-morphological analysis was conducted using a polarized light microscope. Based on the results, we can demonstrate that 1) the birefringence value of the mature medieval enamel sample ranges from 0.3 to 0.4, which means that medieval enamel has retained its optical properties, although some changes in the inorganic components were found; 2) the mature intact enamel and abraded enamel have a negative optical sign, which is the same as that found in immature enamel; and 3) the mature reduced enamel changes its optical sign due to the phenomena of bending of the surface enamel prisms from 0.7 mm to 0.9 mm. This change of the optical sign results from a rise in temperature during the reduction process and from a diffusion of "non-oriented" molecules. The increased pressure on the enamel during the reduction process causes the bending of the surface part of the enamel prisms. The presence of pigmentation and carious changes in the abraded enamel and ground enamel also indicated the process of diffusion of different molecules, which occurred while the enamel was buried in the soil, as well as during the lifetime of the individual.

Fig. 1. Intact enamel under the polarization microscope. Well-formed clear enamel prisms of different position and of negative optical sign can be perceived (with an analyzer and a gypsum plate at 37X magnification).

INTRODUCTION

Micro-morphological analysis of enamel can be done by using the polarizing light microscope (PLM) and by observing changes in its optic properties. Information can be obtained on its structure, such as the position and direction of the enamel prisms, as well as the maturity of enamel. During maturation enamel loses its inorganic components. This leaves no evidence in the structure, but causes changes in the optical properties of the enamel.

The optical properties of teeth have been studied since the nineteenth century. Valentin (1861) first noticed birefringence (double refraction, which is the difference between the maximal refractive index and the minimal refractive index) of the enamel. He argued that birefringence of the enamel is considerably stronger than that found in dentin or cementum. Valentin (1961) also found negative elongation of the enamel prisms in the direction of its long axis. Hoppe (1962) observed that prisms of mature enamel show a negative optical sign in man and other mammals, while developing enamel varies in optical sign from positive to negative. The phenomenom of the change of the optical sign can be seen following the direction of the prisms. Hoppe (1962) concluded that enamel prisms are uniaxial with the optical axis of the negative beam parallel with the long axis of the prism; more exactly, to the elongation of the prism. Schmidt (1925) also noted the change of the optical sign in developing dental enamel. Cape and Kitschin (1930) showed the values of the common beam (n_o), the uncommon beam (n_e), and the birefringence ($n_o - n_e$) of the natural minerals, apatites, and dental enamel (Table 1). On the basis of radiographic study, the authors concluded that changes of the optical sign of enamel represent a consequence of two different inorganic components persisting within its structure. These are hydroxyl apatite ($Ca_5\ (PO_4)_3OH$) and carbonate apatite ($Ca_5\ (PO_4)_3CO_3$). They display the same X-ray diagram, but an opposite optical character and birefringence of differing strengths. The positive of these is dominant in the first stages of development; the negative one gradually becomes predominant as the enamel matures.

Allan (1959a,b) found that the intrinsic birefringence of hydroxyl apatite may be modified by heating due to the thermal movement of the molecules and the changing of its orientation. Non-oriented liquids would only change their refractive index, which falls as the temperature rises. Calstrom (1962) has analyzed birefringence of minerogenous apatite and found that it is higher (-0.007) (approximately double) than the observed birefringence of enamel (-0.003 to -0.004). Results of later investigations deal with changes of the optical properties of the enamel caused by microabrasion (Waggoner *et al.*, 1989; Segura, 1991; Willis and Arbuckle, 1992; Segura, *et al.*, 1993; Stampe, *et al.*, 1993; Chan *et al.*, 1995).

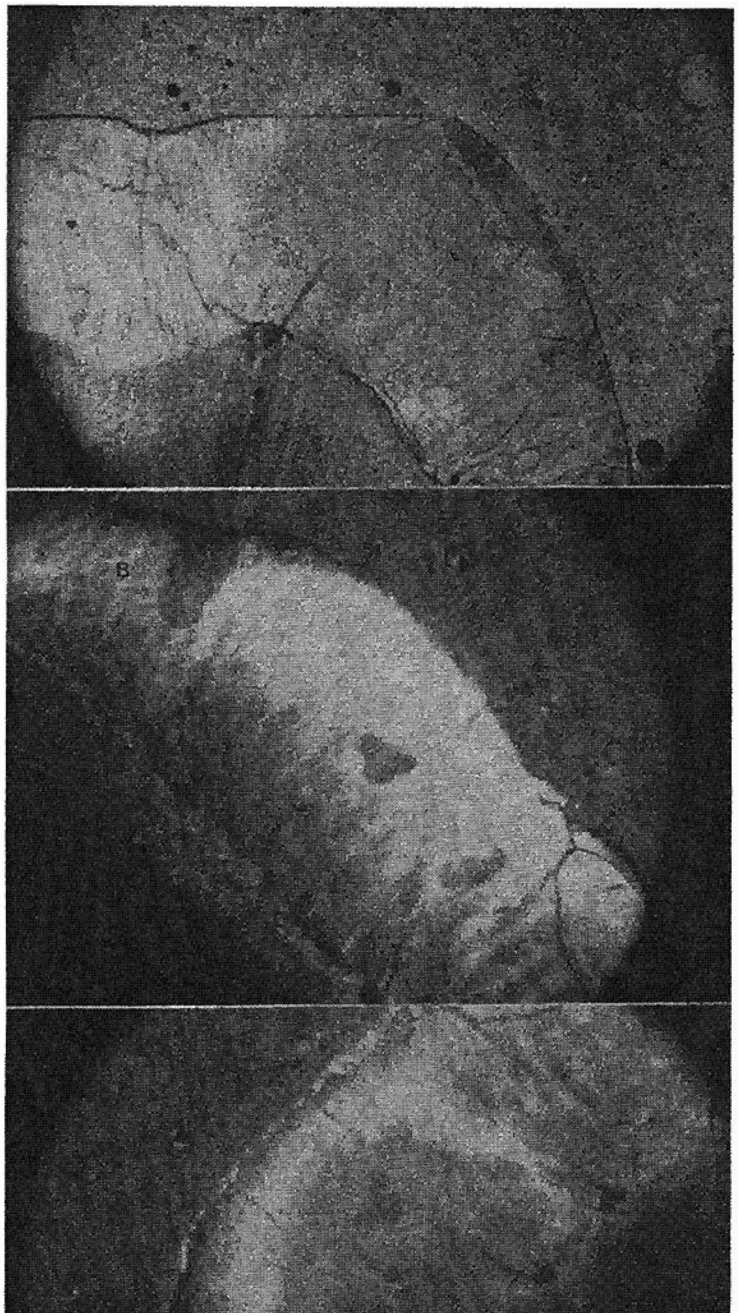

Fig. 2. Abraded enamel under the polarization microscope. The occurrence of pigmentation in the enamel: top) on the surface of abraded enamel (without the analyzer at 42X magnification), center) on the surface and in the enamel itself (with the analyzer at 42X magnification), bottom) on the surface and in the enamel without any change of optical sign (with the analyzer and the gypsum plate at 42X magnification).

AIM OF THE STUDY

In the present study the differences in the optical characteristics of samples of intact, abraded, and reduced enamel were analyzed. Intact enamel was obtained from archaeological material in order to investigate the influence of the diagenesis (changes in composition of inorganic components) of enamel and its structure. We believed that evidence of diagenesis could be seen only in the optical properties of enamel. Mechanically (artificially) reduced enamel was used to compare its optical properties with the properties of naturally abraded (worn) enamel resulting from the process of mastication.

MATERIALS

Twenty-one teeth from adult individuals, unearthed at the late medieval cemetery of Stara Torina located in the North of Serbia were examined in this study. Archaeological investigations of the necropolis indicate that the period of burial interment probably took place between the twelfth and the seventeenth centuries. Anthropological analysis of the skeletal remains of nearly 800 individuals is being done at the Laboratory for Anthropology. The material used in the study was divided into three categories: 1) samples of intact enamel (N=7) (Group A); 2) samples of abraded (horizontal, vertical and mixed cuts) enamel (N=7) (Group B); and 3) samples of intact reduced enamel (artificially removed superficial layer) (N=7) (Group C).

METHODS

Non-decalcified teeth were vertically cut using a low speed saw with a rotating circular disk impregnated with diamond dust. Enamel sections were mounted in Canadian balsam, which has a refractive index of 1.537, and placed on glass slides measuring 25mm x 50mm x 0.17mm.

To study the optical properties of enamel a polarizing light microscope (Reichert, Neovar, Pol) fitted with the following equipment was used: 1) a polarizer without an analyzer, which allows the light to pass through in one direction only, thus limiting the oscillation of the light to one plane; 2) a polarizer with an analyzer (Nikoli+), which allows only the light oscillating perpendicular to the first one to pass through, because the orientation of the oscillation planes of the polarizer and the analyzer is opposite to each (The anisotropic crystals can only be seen with the crossed Nikol's.); 3) a cast tile or a gypsum plate which is placed in the tube-slot of the microscope and orientated in the -45° position, which establishes a sign of optical elongation. Examination of the material was accomplished in three steps: 1) examination with a polarizer; 2) examination with a polarizer and an analyzer; and 3) examination with a gypsum plate. The three groups of specimens were analyzed at a magnification ratio of 40:1.

The strength of birefringence of the objects is obtained indirectly by determining the path difference (Δ) measured with a Berek's compensator. The experimental strength of the birefringence obtained can be obtained using the equation $(\epsilon-\omega) = \Delta/d$, where ϵ is the refractive index of the common beam; ω is the refractive index of the uncommon beam (anomalous dispersion); Δ is the path difference; and d is the thickness of the section of the object (from which the path difference is calculated). The difference between the maximum and minimum refractive index ($n_o - n_e$) gives the strength of birefringence (n_o is the common beam; n_e is the uncommon beam).

RESULTS

Significant differences in the optical properties of dentin, enamel, and cementum have been reported. Considerably stronger birefringence of the enamel in comparison with dentin was observed. Analysis of each group is given separately.

Group A - Samples of Intact Enamel

Examination with a polarizer (without an analyzer) demonstrated the presence of non-homogenous stained enamel with regions of bright and dark yellow color. The mature enamel is composed of prisms consisting of bundles of apatite crystals (from 0.3333 mm to 0.8325 mm in length and about 30 nm to 40 nm in diameter) oriented at right angles to the surface.

Examination with an analyzer (Nikoli+) revealed significant birefringence of enamel. Measured with a Berek's compensator, the birefringence value ranged from 0.0037 to 0.0400. Crystals of hydroxylapatite are elongated and oriented parallel with the relatively longer axis of the prisms. These prisms become somewhat bent toward the enamel surface. In addition, the optical axis of the crystal was incongruent from those of the prism's relatively longer axis, and differences from 0 to 20 were found, mostly in the peripheral zone of enamel.

Examination with a gypsum plate showed the optical sign of crystal elongation within the prisms to have mostly negative values. This is particularly in the peripheral zone of the enamel, as well as in the contact zone toward the dentin. The interference colors of those prisms appear bluish-white. An area of comparatively lower birefraction is commonly observed in the middle zone of the enamel. Intermittently crossed prisms of diazone and parazone with optically positive and negative birefraction occur in the middle zone of the enamel. Because of the tangential intersection of the parazone, which is cut toward the relatively longer axis of the tangential plane, its birefraction has a higher value than those of the diazone, which is cut transversely. Interference colors in this area are mostly abnormal: yellowish-brown and indigo-blue; that is, the manifest of dispersion of birefraction for different wavelengths in the visible part of the spectra (Fig. 1).

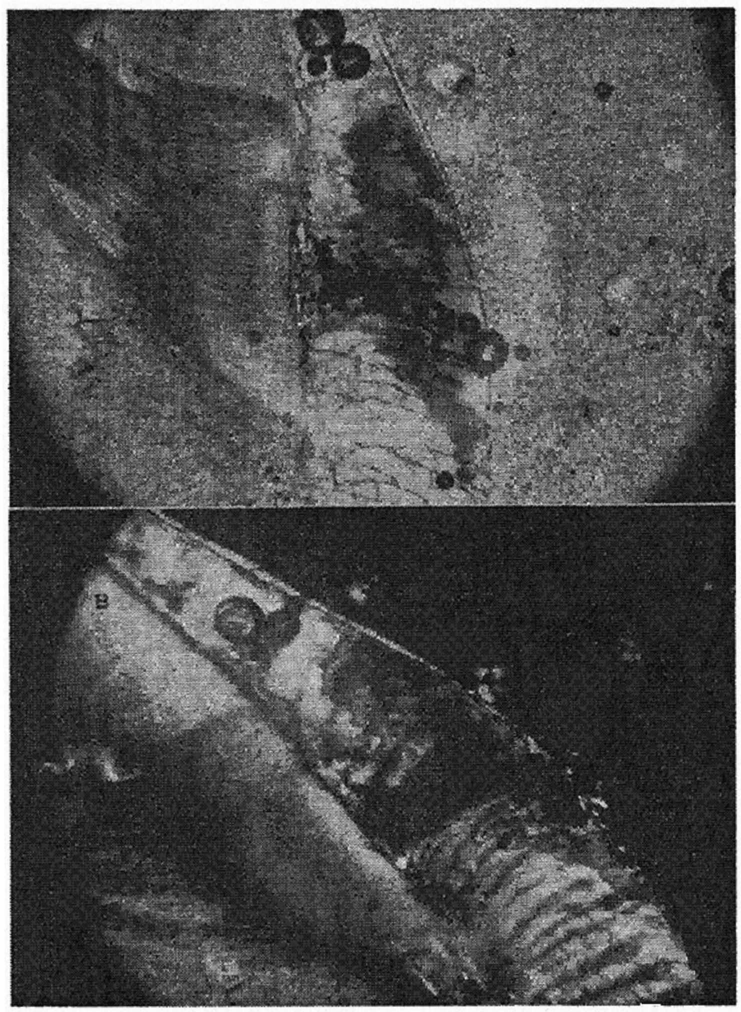

Fig. 3. The abraded enamel under the polarization microscope: top) distinct polychromy on the surface due to changes in the structure and chemical composition of the enamel (without the analyzer at 28X magnification); bottom) visible anomalous interferential colors on the surface of the changed enamel (with the analyzer at 28X magnification).

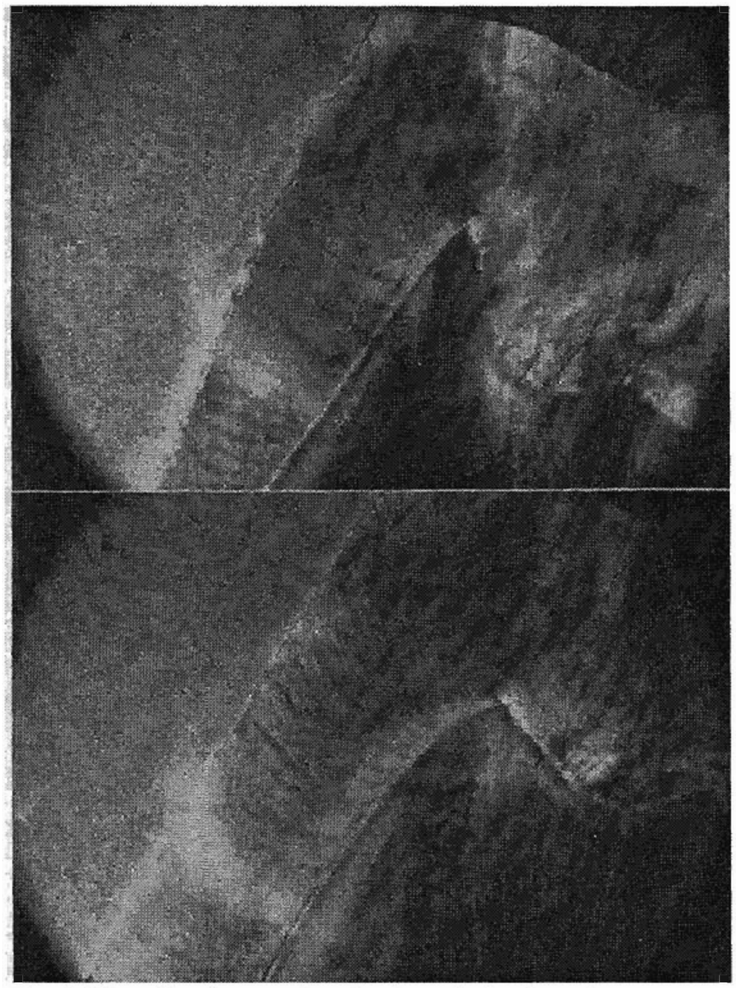

Fig. 4. The reduced enamel under the polarization microscope. On the surface of the reduced enamel tissue the following can be perceived: top) an intensive bending of enamel prisms and a change of the optical sign (with an analyzer and a gypsum plate at 25X magnification); and bottom) an intensive change of the optical sign that can be noticed through the occurrence of the blue interferential color on the enamel tissue (with an analyzer and a gypsum plate at 25X magnification).

Group B - Samples of Abraded Enamel

Examination of abraded enamel with a polarizer without an analyzer revealed the presence of pigmentation in ome areas of the surface, as well as beneath it (Fig. 2 top). Examination with a polarizer and an analyzer (Nikoli+) revealed oval-bordered grayish areas in regions of pigmented enamel. Prisms located under the abraded surfaces are orthogonally cut, which is also characteristic of corroded enamel (Fig. 2 center).

Examination with a gypsum plate revealed areas of pigmentations, as well as prisms cut orthogonally. However, the most important observation was the optical sign of abraded enamel. The abrasion process removes the surface layer of enamel, but the value of the optical sign and the optical elongation remains unchanged (negative) as the result of inner dual refraction of hydroxylapatite (Fig. 2 bottom).

In several cases carious lesions were found at the abraded surfaces. These cases were analyzed separately. Examination of the carious lesions with a polarizer (without an analyzer) showed that the polychromatic nature of the sample's surfaces resulted from the structural and chemical changes of the abraded enamel.

A brown color was observed in the area of a carious lesion indicating the existence of turbid media, which consists of at least two components with different indices of refraction (hydroxylapatite and gasses or liquids). Dichromatism and coloration of these zones indicate the high concentration of some element (iron in this case) which directly influences the absorption of some wavelengths in the visible part of the spectra. The zones of caries lesions are clearly visible in Fig. 3 top and bottom.

Examination of the zones of carious lesions with an analyzer (Nikoli+) show these areas to be anomalies with the interference of colors evidenced, as well as brown-colored areas with intermittent positive and negative birefringence. In addition, anomalous yellowish-brown colors were observed in some dark zones of enamel (Fig. 3 bottom).

Group C - Samples of Ground Enamel

Examination of ground enamel with a polarizer and an analyzer (Nikoli+) indicated similarities with the observations obtained from the samples of intact enamel from Group A. Enamel prisms of those samples are sharp and clear.

Examination with a gypsum plate revealed that the optical sign of ground enamel is changed from that of intact enamel. The change in the optical sign is seen in a blue interferant color at the surface of the enamel. We believe that this change is due to the grinding of the enamel surface. Ends of prisms are bent or break during the grinding process (0.0730 mm to 0.0999 mm) (Fig. 4 top and bottom). In addition, negative elongated prisms were observed.

DISCUSSION

The enamel of the contemporary sample and the mature enamel of the medieval sample shows inner dual refraction of hydroxylapatite (a negative optical sign), which is interpreted to mean that the samples of enamel studied kept their optical properties during the long-term interment in the soil. Comparisons of the range of birefringence obtained in the study with the values of birefringence from Table 1 suggest that some changes in the composition of exhumed enamel occurred. The enamel that we examined consists mainly of fluorapatite ($Ca_5(PO4)_3F$), while the range of hydroxyapatite (normally the main constituent of the inorganic component of enamel) was very low. This evidence suggests that teeth, once buried, undergo chemical reactions with the environment in which hydroxyl ions are replaced chemically by other ions such as fluoride. The process of substitution by the fluoride ion is still unclear and requires further research.

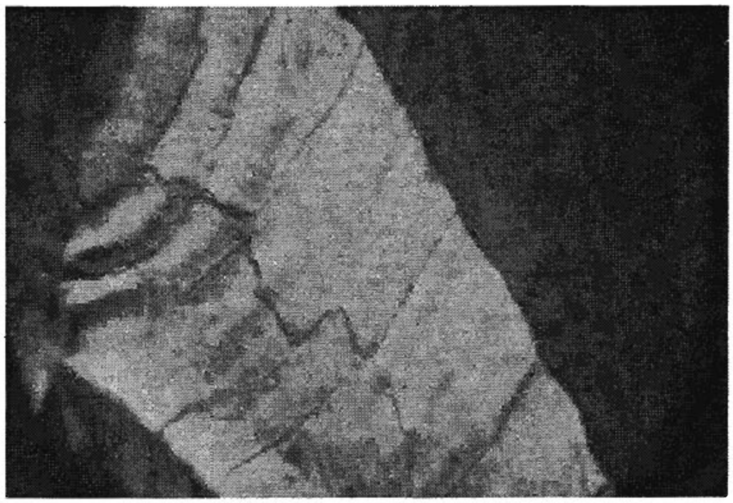

Fig. 5. Reduced enamel under the polarization microscope. Prisms are elongated in a negative way with distinct easy cutting of the reduced enamel tissue visible (with an analyzer and a gypsum plate at 63X magnification).

The loss of the surface enamel layer in abraded enamel did not change the optical sign. On the contrary, grinding of enamel resulted in the reverting of the optical sign, which was followed with bending of enamel prisms from 0.0730 mm to 0.0999 mm.

Changing of the optical sign of ground enamel is not a consequence of removal of the surface layer. This is confirmed by the absence of optical sign changes within abraded enamel, which also has undergone reduction of the surface layer. The changes in the optical sign are the result of exposure of enamel to heat by grinding. The heat induces the changes of the inner dual refraction of hydroxylapatite, causing movements of the molecules thermally and changing their orientation. Further diffusion of liquids with un-oriented molecules into the ground enamel leads to changes of the refraction index. Lowering of the index is proportional with the rising of the heat, consistent with the results of Allan (1959a,b).

Bending of the outer part of enamel prisms results from the high pressure developed by the grinding process, which allows prisms to be along their relatively longer axis. In the abraded enamel the mechanism of reduction is different, resulting from friction and pressure occurring over a comparatively longer period of time and under relatively less pressure without excessive heat. Such a mechanism results only with the possibility of cutting of prisms through their comparatively longer axis, which does not affect the optical sign. The parts of pigmented enamel discovered indicate the possibility of the diffusion of different molecules into the enamel.

CONCLUSIONS

Based on the evaluation of the results obtained from the analysis of the optical properties of intact, abraded, and ground enamel, we concluded the following:

1. Dental enamel from buried remains kept its optical properties. Birefringence of the mature enamel of medieval skeletons ranges from 0.0037 to 0.0040, which suggests some changes in the constituents of the inorganic components of the enamel.
2. Mature intact and abraded enamel shows a negative optical sign. Mature enamel, which has been artificially ground down, changes its optical sign to neutral or positive. Furthermore, bending of the outer parts of enamel prisms from 0.0730 mm to 0.0999 mm occurs. Changing of the optical sign is induced by the heat developed by grinding and the diffusion of un-oriented molecules into the ground enamel. Bending of the outer portion of enamel prisms is a consequence of the pressure produced by the grinding process.
3. Cutting of the prisms through their relatively longer axis, pigmentation, and carious lesions observed on the abraded and ground enamel indicate that processes of diffusion of various molecules are active while the enamel is buried in the soil, as well as during the lifetime of the person.

TABLE 1. Values of the common ray (n_0), the uncommon ray (n_e), and the birefringence (n_0 - n_e) of natural minerals, apatites, and enamel as modified from Cape and Kitchin (1930).

Apatite	n_0	n_e	Birefringence
Fluorapatite ($Ca_5(PO4)_3F$)	1.633-1.650	1.629-1.646	0.003-0.005
Hydroxyl apatite $Ca_5 (PO_4)_3OH$	1.643-1.658	1.637-1.654	0.007-0.004
Carbonate apatite $Ca_5 (PO_4)_3CO_3$	1.633-1.655	1.630-1.651	0.004-0.0043
Enamel	1.6277	1.6234	0.0043

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DENTAL ANTHROPOLOGY AT THE UNIVERSITY OF OREGON

GUY L. TASA[1] AND DEBBIE GUATELLI-STEINBERG[2]

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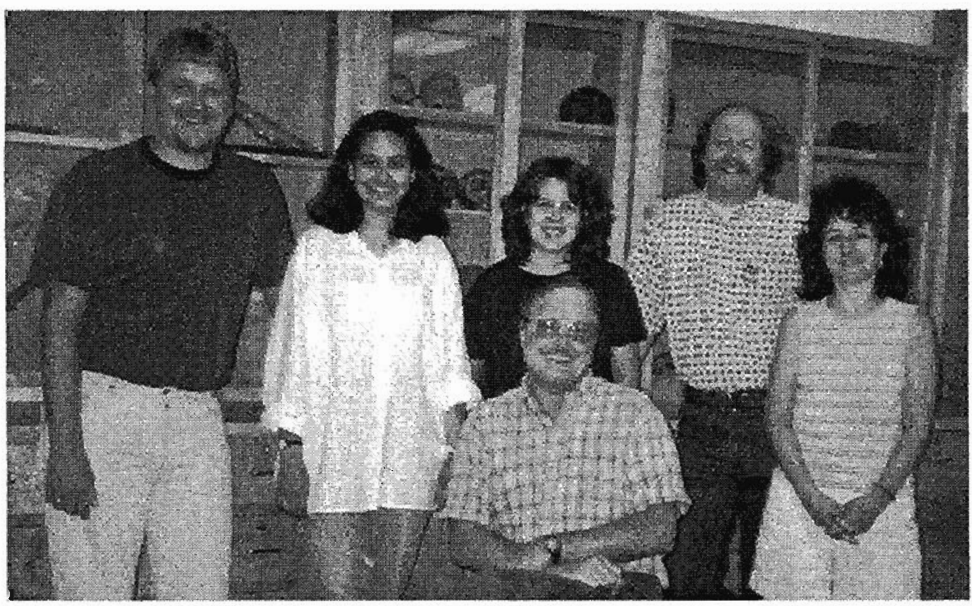

Fig. 1. Guy Tasa, Samantha Bhiladvala, Darcy Hannibal, Greg Nelson, Debbie Guatelli-Steinberg, and John Lukacs (sitting) in front of the teaching collections in the Department of Anthropology at the University of Oregon.

Dental anthropology continues to flourish at the University of Oregon (UO), with additions to skeletal collections and an increasingly diverse set of faculty and student research endeavors (Fig. 1). The UO's State Museum of Anthropology (SMA) and Department of Anthropology both house collections available for study. The SMA served as the state repository for Native American skeletal remains collected before the enactment of Oregon's Indian burial law, and, although most of the collection is slated for repatriation under NAGPRA (Native American Graves Protection Act) in the very near future, it is still available for analysis by qualified researchers. While conducting archaeological recovery projects for various agencies, the SMA also occasionally recovers human skeletal remains which are typically studied after consultation with appropriate local Native American groups. The Department of Anthropology maintains a collection of 1,800 dental casts of modern South Asians from eleven different ethnic/caste groups. In addition, the department has a large primate skeletal collection donated by the Oregon Regional Primate Research Center complete with life history data.

Former president of the Dental Anthropology Association, **John Lukacs**, has initiated numerous research projects this year. He received two UO grants supporting research on dental enamel defects in primary teeth. Lukacs traveled to the Cleveland Museum of Natural History and the Smithsonian Institution to study enamel defects in great ape primary teeth. The results of this research are presented in an article entitled "Enamel hypoplasia in the primary teeth of great apes: Do significant differences in prevalence reflect differential levels of stress?" The article is currently under review by the *Journal of Human Evolution*. He conducted summer research on enamel defects in the primary teeth of prehistoric populations. Lukacs presented a paper at the Paleopathology Association meeting in Salt Lake City entitled "Enamel defects and subsistence transitions in ancient India." His presentation summarized highlights from "Physiological stress in prehistoric India: New data on localized hypoplasia of primary canine teeth (LHPC) linked to changes in climate and subsistence," an article co-authored by Subhash R. Walimbe (Deccan College, India), which appeared in the June issue of the *Journal of Archaeological Science*. Lukacs recently received a grant from the Wenner Gren Foundation that will fund travel to India for an epidemiological study of enamel defects in the primary teeth of children.

Guy Tasa, Human Osteologist at the SMA, recently (Ph.D. Fall 1997) defended his doctoral dissertation: "Skeletal and dental variation of Pacific Coast Athapaskans: Implications for Oregon prehistory and peopling of the New World." Tasa's article in this issue of *Dental Anthropology* concerns a case of connate teeth from the Middle Columbia River Valley. He is amassing a large volume of case history data on the trait and plans to publish a paper summarizing these studies. Tasa's article, "Three-rooted Mandibular Molars in Northwest Coast Populations: Implications for Oregon Prehistory and Peopling of the New World," appears in the Dahlberg memorial volume. Tasa is also collaborating with Michael Pietrusewsky (University of Hawaii-Manoa) on research of dental remains from Pohnpei, Micronesia, and with Lukacs on research involving localized enamel hypoplasia in Native American deciduous teeth.

Greg Nelson (Ph.D. Winter 1998) also recently defended his doctoral dissertation: "Occlusal variation in modern India." Nelson, along with John Lukacs and Paul Yule (Deutches Bergbau Museum, Germany) has an article in press with AJPA entitled "Dates, caries, and early tooth loss during the Iron Age of Oman." Nelson's paper, "Physiologic stress and environmental fluctuation in the northern Great Basin," will be published in the University of Utah monograph: *Understanding Prehistoric Lifeways in the Great Basin Wetlands: Bioarchaeological Reconstruction and Interpretation*, edited by B. E. Hemphill and C. S. Larson.

This fall, **Debbie Guatelli-Steinberg** will defend her dissertation: "Prevalence and etiology of linear enamel hypoplasia in non-human primates." She earned a National Science Foundation grant to support her dissertation research. Guatelli-Steinberg has an article, co-authored by John Lukacs, in press with the *American Journal of Physical Anthropology*, entitled "Preferential expression of linear enamel hypoplasia on the sectorial premolars of rhesus monkeys." The article reports a novel intertooth pattern in the expression of linear enamel hypoplasia (LEH). She and Mark Skinner (Simon Fraser University, Canada) have collaborated on a paper about LEH in sympatric monkeys and apes. The paper is currently under review by *Folia Primatologica*. Guatelli-Steinberg also presented a paper, entitled "Linear enamel hypoplasia and life history in Cayo Santiago rhesus monkeys," at the American Association of Physical Anthropologists' meeting in Salt Lake City.

Samantha Bhiladvala (M.S. Spring 1998) recently completed her master's thesis: "*Foremen Caecum Molare*: Prevalence among the Marathas and Madia Gonds of India." She hopes to submit a revised version to the *American Journal of Physical Anthropology*. **Darcy Hannibal**, a new student in the masters' degree program, is currently working with Lukacs on the occurrence and timing of localized hypoplasia in great ape primary canines. She looks forward to conducting research on LEH in pongids. This fall, three students with interest in dental anthropology plan to enter the UO Graduate Program in Anthropology: **Aimee Potter** (doctoral program), **Megan Moore** (masters' program), and **Gwen Robbins** (masters' program).

Finally, the UO Department of Anthropology is pleased to announce the publication of University of Oregon Anthropological Papers No. 54, entitled *Human Dental Development, Morphology, and Pathology: a Tribute to Albert A. Dahlberg*, edited by John Lukacs. You can visit the UO's Department of Anthropology online at: http://darkwing.uoregon.edu/~anthro/ and the UO's State Museum of Anthropology - Museum of Natural History at: http://oregon.uoregon.edu/~mnh/index.html.

REPORT FROM THE PRESIDENT

JOHN T. MAYHALL
Faculty of Dentistry, University of Toronto, 124 Edward Street, Toronto, Ontario, M5G1G6, Canada

Dental anthropology is alive and well! I have returned from a stint as a visiting professor at Nihon University with renewed vigor and appreciation for our field. The Japanese Dental Anthropology Association has over 100 members, many of whom are also members of our organization. When the Dental Anthropology Association was formed I was reluctant to join and, in fact, didn't do so for several years. I thought that another anthropology organization was the last thing that we needed. Over time I have changed my mind primarily for one reason, the journal. With our new title, Dental Anthropology, and an emphasis on papers that are peer reviewed before they appear in the journal we are at the beginning of a new era that will, I believe, give dental anthropology a higher profile. A feature of the journal that has held my interest over the years is the section that lists papers of interest to dental anthropologists. I hope that this will continue under the direction of David Gantt. His last compilation was up to the thorough standards of the previous ones. It is obvious that the journal has achieved what it has because of its editors, most recently Sue Haeussler. Thanks Sue! We are communicating with the world through our web-site as well Phil Walker has been instrumental in producing a site that we can be proud of. I want to thank Phil for the tremendous job he did as president of the DAA, as well as on the web-site.

Two important items should be brought to the members' attention. First, I have asked Loring Brace to initiate a study of the best way to institute the Albert Dahlberg prize for student papers. We will have more information about this soon. If anyone has any suggestions please contact Loring.

Second, Loring and Phil also have worked hard to represent the DAA's views on the Hastings Amendment. After their careful crafting of a letter I signed it and faxed it to Representative Don Young. The text follows:

The Honorable Don Young, Chairman
House Resources Committee
1324 Longworth House Office Building
Washington, D.C. 20515

Dear Representative Young:

The Dental Anthropology Association is pleased to hear that the House Resources Committee will have a hearing to consider HR 2893, an amendment to the Native American Graves Protection Act (NAGPRA).

The Dental Anthropology Association is an international scientific organization whose members share research interests in the oral health and dental morphology of modern and ancient human populations. At our recent annual meeting our members unanimously voted to support the passage of HR 2893.

Our members support this amendment because it will allow scientific research to continue to enhance our understanding of the past and, at the same time, protect the ability of Native American tribes and Hawaiian organizations to determine the disposition of culturally affiliated human remains and cultural items.

HR 2893 accomplishes this by eliminating the provision of NAGPRA that provides for repatriation of recently excavated cultural items to culturally unaffiliated groups based on recent land use. It also enhances scientific recording and study of human remains, funerary objects, sacred objects, and objects of cultural patrimony before their repatriation under NAGPRA. Finally, HR 2893 clarifies the disposition of inadvertently discovered cultural items. The amendment accomplishes these objectives without diminishing the capacity of culturally affiliated tribes or Native Hawaiian organizations to repatriate ancestral remains.

Passage of this bill would help scientific understanding of the past for the benefit of the American public while maintaining Native American rights and sovereignty. The Dental Anthropology Association urges your Committee support to this bill.

John Mayhall, PhD, DDS
President, Dental Anthropology Association

If you were at the business meeting in Salt Lake City you will recall that we unanimously recommended that the association take action to show our support for this bill.

Finally, I want to thank our membership for their support. The most tangible aspect of it is the journal but there is an underlying support which is the word of mouth about ourselves and what we do. We depend on our members to "get the word out" about the benefits of belonging to the DAA. We have a strong organization that will become even stronger with more members. Take a friend to lunch and force him/her to join the DAA! The membership is probably cheaper than the lunch.

If you feel lonely feel free to write to me. I want to hear how we can make your organization work for you.

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JAPANESE DENTAL ANTHROPOLOGY ASSOCIATION FORMED

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The first meeting of the Japanese Dental Anthropology Association was held at the Nihon University School of Dentistry at Matsudo on July 11th. The fledgling organization already has over 100 members. The scientific program organized by Eisaku Kanazawa and Ikuo Kageyama featured six papers. These were "Tubercle-shape Incisors of Polynesian People" by Hiroyuki Yamada and Hajime Hanamura,"Tooth Shape Analysis Based 3-D Data Adjusted to the Quantitative Axes" by Masakuni Takagi and Takashi Ikuta, "Measurement of the Crown Components in the Mandibular Molars" by Shintaro Kondo, "Dental Palaeopathology: The present and the future" by Hisashi Fujita, "A Morphological Study of Tooth and Periodontal Tissues from a Clinical Standpoint" by Miyoko Matsue, and "Dental Anthropology and the Human Environment; Do we know the 'cause' of dental trait expression?" by John Mayhall. There was lively discussion of the papers and it was obvious that this dental anthropology organization is off to a fine beginning. Plans are already underway for next year's meeting.

TRANSITIONS

Diane Hawkey has accepted an appointment as Visiting Assistant Professor of Biological Anthropology at SUNY-Binghamton for the 1998-1999 academic rear. Plans include a graduate seminar course in Dental Anthropology during the fall semester.

Joel Irish is now employed at the University of Alaska-Fairbanks. He is Assistant Professor in the Department of Anthropology and Curator of Physical Anthropology (UAF Museum).

NEW BOOK

Human Dental Development, Morphology, and Pathology: A Tribute to Albert A. Dahlberg has been published by the University of Oregon Anthropological Papers. Edited by John Lukacs, the volume is a collection of papers presented at the Albert A. Dahlberg Symposium on Dental Morphology and Evolution during the annual meetings of the American Association of Physical Anthropologists in 1995. Individuals wishing to purchase the book can contact the Department of Anthropology, 1218 University of Oregon, Eugene, OR 97303-1218, USA (telephone 541-346-5102, fax 541-346-0668. The cost of the book is $40.00 plus shipping and handling ($3.00 U.S.A., $9.00 international) and is payable by cash, check, VISA, and MASTERCARD.

MEMBERSHIP IN THE DENTAL ANTHROPOLOGY ASSOCIATION

Information about membership status and new members can be obtained by contacting Stephen C. Reichardt, the Dental Anthropology Association secretary-treasurer, at the Department of Anthropology, Arizona State University, Box 872402, Tempe AZ 85287-2402, or by email at SRSRS@imap2.asu.edu. Membership extends for a calendar year. Renewal of membership is due on January 1, 1999. A membership form is included in the envelope with this copy of *Dental Anthropology*.

GUIDELINES FOR CONTRIBUTORS TO *Dental Anthropology*

Dental Anthropology uses the following guidelines.

1. Articles have short abstracts. Text format, citation, and abbreviation styles follow those used by *American Journal of Physical Anthropology*. However, names of journals that are not familiar to readers are spelled out. The feature, *Dental Anthropology Bibliography*, contains unabbreviated citations.
2. Illustrations and photographs enhance articles and are encouraged. They will be returned, if the authors so request. Graphs should be accompanied by a table containing the data, even if the table is not to be published. In that way, the editor can construct a new graph if the one submitted presents problems in formatting.
3. Two copies of each manuscript should be submitted. The second copies of illustrations can be photocopies. Contributors are also asked to send a copy of the manuscript on diskette, if possible. The newsletter uses IBM© format and *Word Perfect* 6.1©.
4. All manuscripts are reviewed by a member of the editorial board. In cases of specialized topics, manuscripts are reviewed by a specialist in the topic of the manuscript.
4. Deadlines for manuscripts and membership lists for the next issues are November 15, 1998, and March 15, 1999. Manuscripts received after these dates will be considered for future issues.

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[1]The bibliography was created in EndNotes™. A copy of the file is available from David Gantt *dggantt@bellsouth.net* or dgantt@*iname.com.* Also, if you have published a recent paper which has not been cited, please email your information to David Gantt at the above address.

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MINUTES FROM THE 1998 THIRTEENTH ANNUAL MEETING OF THE DENTAL ANTHROPOLOGY ASSOCIATION, SALT LAKE CITY, UTAH, APRIL 2, 1998

I. **PRESIDENTIAL ADDRESS** (Phil Walker):
The meeting is called to order at 7:30 p.m. Phil Walker calls for the secretary-treasurer's report.

II. **REPORT OF THE SECRETARY-TREASURER** (Stephen C. Reichardt)

A. **Status of the Treasury** As of March 31, 1998, the Dental Anthropology Association's net assets are $4,134.47 compared to $3,634.57 one year ago. The 1998 balance can be broken down into two categories: $3,134.47 in a checking account and $1000.00 in a certificate of deposit earning interest at a fixed rate of 4.75% per year. Upon maturity, the certificate of deposit will automatically be renewed unless the bank is notified by the secretary-treasurer. In addition, the interest rate may be reevaluated if it is advantageous to do so.

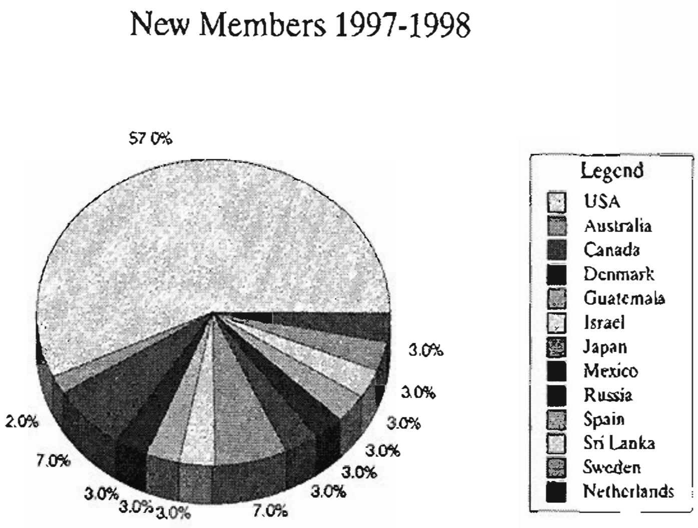

Fig. 1. Countries of origin and their percentages of new members who joined the Dental Anthropology Association between the 1997 and 1998 annual meetings. Countries are ordered clockwise, beginning with USA at 57.0%.

Of the $3,134.47 in checking $70.36 is available to sponsor eligible international members.

The estimated total annual expenses incurred by the DAA were $2290.20 which can be broken down as follows: $1210.74 for printing costs, $654.46 for international postage, $300.00 for phone, and $125.00 for VISA/MC account maintenance. In addition, a one time expense of $961.68 was incurred for the purchase of a computer for the Association.

B. **Membership Status** As of March 27, 1998, the DAA has 356 members. This number is up 43 from one year ago. During the past year the association acquired 43 new members, but were forced to delete 45 for non-payment. 222 members are from the U. S. and 134 are international. The DAA office continues to contact overdue members in an effort to collect fees rather than delete members. As of March 27, 217 members (61%) are past due for 1998.

III. **ELECTION OF NEW OFFICERS**

A vote was taken by show of hands to elect new officers. Unanimous votes brought about the following election results: John Mayhall is now the new President, followed by Edward Harris as the new president-elect, and David G. Gantt as the new executive board member. A. M. Haeussler continues as the editor of *Dental Anthropology*.

IV. **VOTE ON BY-LAW CHANGES**

A vote was taken by show of hands on changes to the affected articles of the current by-laws as stated in Dental Anthropology Volume 12, Numbers 2-3, 1998 page 18. A unanimous vote in favor of the stated changes to the by-laws was passed.

V. **NEW BUSINESS**

A. **Elections** Ideas were proposed to revise our current procedure of electing officers. Phil Walker stated that the voting process needed to be open to all DAA members and not just those who attend the annual business meeting. The idea of mail-in ballots was discussed and was generally well received. The executive committee will examine the logistics of the new procedure.

B. **The Albert A. Dahlberg Award** John Mayhall and Loring Brace agreed to initiate a study of the best way to institute the Albert Dahlberg prize for student papers. Their results will be published in a forthcoming volume of *Dental Anthropology*.

Two ideas were put forward in order to augment the proposed cash prize. First, the winning paper would be considered for publication in *Dental Anthropology*. Second, the donation of calipers was considered. Discussion over the first idea led some to the conclusion that the winning author may wish to submit his or her paper to another Journal. A final decision on these matters was not reached.

C. **HR 2893, an amendment to the Native American Graves Protection (NAGPRA)** This would allow scientific research to continue and, at the same time, protect the ability of Native American tribes and Hawaiian organizations to determine the disposition of culturally affiliated human remains and cultural items. A unanimous vote was made in support of the passage of HR 2893.

D. **Control of the Dental Anthropology name** David Gantt will continue the work originally begun by Phil Walker to gain control of the Dental Anthropology name.

VI. **ALL OTHER NEWS-ANNOUNCEMENTS**

A. **The Albert A. Dahlberg Volume** John Lukacs mentioned that the volume is near completion and should be out by the end of March, 1998. This volume is a compilation of papers presented at the Albert A. Dahlberg symposium in Oakland California March 30, 1995.

B. **11th International Symposium on Dental Morphology** John Mayhall mentioned that this symposium held at the University of Oulu, Institute of Dentistry, Oulu, Finland, will be held August 26-30, 1998. John feels that due to the wide range of dental sessions, anyone who can, should try and attend this Symposium. These sessions will be chaired by DAA member Lassi Alvesalo.

C. **Web Site** Phil Walker reports that the DAA Web Site is up and running. Thanks was given to Shara Bailey for her excellent work on the design of the DAA web site. Phil Walker's intention for the web site is that it will be used as a teaching aid in which images of teeth can be down loaded from the system. The address of the web site is www.sscf.ucsb.edu/~walker/html.

The thirteenth Annual Dental Anthropology Association Business Meeting adjourned at 8:30 p.m.

Respectfully submitted,
Stephen C. Reichardt

Dental Anthropology
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