

The Dental Health Status of Pre-Columbian Peruvians: A Study of Dental Caries, Missing Teeth, Attrition, Osteitis, Calculus, and Bone Loss

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Prior to the recent reports of Sawyer et al¹ and Elzay et al² on the characteristics and dental health status of ancient Peruvian cultures, only Stewart³, Leigh⁴, and Goaz and Miller⁵ had reported on the dental morphology and pathology of the pre-Columbian Peruvian Indians. The purpose of this study is to evaluate the dental health of these ancient peoples to further our understanding of the development of dental diseases. This paper follows up and expands the report of Elzay et al² to include another culture and

completely new specimens, with a look at primary dentitions not previously available for study.

Materials and Methods

The permanent maxillae from 115 individuals, and 113 permanent mandibles along with 46 individual primary maxillae and their primary mandibles, separated by cultural groups, were included in this survey. Only four specimens were found which had a mixed dentition and these were not included in this study. Thus, those maxillae and mandibles labeled permanent had only permanent dentitions and those labeled primary had only primary dentitions. All examinations were completed by gross examination of materials with dental probes and explorers under op-

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timal light. A dental radiographic unit was available and x-rays were used to confirm diagnoses.

The only teeth counted as missing were those apparently lost prior to death as shown by osseous healing in the edentulous area. Third molars were considered congenitally absent if there was no evidence of previous tooth loss and subsequent repair, or if they did not show on x-ray or were not grossly present. If the third molar crown appeared within the bone but had not completely erupted, the tooth was classified as either semi- or unerupted.

Attrition or abrasion with no gross loss of crown enamel was scored as 0; the tooth was scored as 1 if enamel loss on the cusp tips did not involve the grooves and fissures, as 2 if the enamel loss involved the grooves and fissures, and as 3 if the process eliminated the grooves and fissures on the occlusal surface. This system differs from the Attrition Index of Lavelle⁶ only in omitting a fourth category for teeth having pulp exposure from attrition and in recording the highest score (most severe) noted on the specimen in lieu of individual scores for all teeth of the specimen.

The incidence of dental caries was recorded in two ways. First, caries were recorded according to the DMFS (decayed, missing, filled surfaces) index. If a tooth had a carious lesion involving only one of its five surfaces, that is, mesial, distal, buccal, lingual and occlusal (incisal), it was scored as 1. A missing tooth (antemortem) or one with all five surfaces carious received a score of 5. This system denotes severity of disease whereas reporting the percent of teeth affected reports only the caries rate. The second method of recording specimens was a modification of the DMFS index. While most teeth today are lost as a result of dental caries, teeth may have been lost in ancient times through trauma, periodontal disease, or pulpitis from severe attrition. Hardwick⁷ developed a method, attempting to correct this; however, it is more meaningful to express caries incidence by omitting missing teeth. Hence, dental caries involvement is expressed as DS (decayed tooth surfaces) per tooth and jaw (specimen).

The condition of osteitis was recorded as present or absent only. Gross evidence of either bone destruction and/or proliferation with or without a fistulous tract was recorded as osteitis.

The degree of calculus formation was indicated as light if less than 1 mm of calculus was deposited on the lingual surfaces of the anterior teeth, moderate if concomitant deposition around posterior teeth was

less than 1 mm, and heavy if calculus deposition on anterior or posterior teeth exceeded 1 mm.

Bone loss was recorded on a scale of 0 for no gross evidence, 1 for interdental bone loss between adjacent teeth, 2 for bone loss down to the bifurcation area of the roots, and 3 for bone loss beyond the bifurcation area. In any one jaw specimen only the most severe manifestation of bone loss was recorded.

Results

The results for the permanent dentitions and jaws are tabulated in Tables 1, 2 and 3, while the results for the primary dentitions and jaws are tabulated in Tables 4, 5 and 6. Individuals from the Ica culture and the Paracas culture (Table 1) exhibited the highest incidence of missing teeth in the maxillary arch, those from the Colonial culture showed the highest incidence of missing teeth in the mandible. The Nazca culture Indians followed by those of the Huari culture showed the fewest missing teeth in both arches. The Ica and Paracas culture Indians showed the highest incidence of missing first, second, and third molars in the maxillary arch while the Paracas and Colonial culture Indians had the highest incidence of missing first, second, and third mandibular molars. Individuals from the Paracas culture followed by those from the Colonial culture showed the highest incidence of congenitally missing third molars in both arches.

The Paracas, Ica and Colonial Indians had the highest incidence of dental caries in both arches in the permanent dentitions (Table 2). Nazca culture Indians showed a low incidence of dental caries while the Incas showed the lowest of all. In individuals with the permanent dentitions, those from the Nazca and Inca cultures had the highest incidence of osteitis in the two arches. The Paracas, Ica and Colonial Indians had the highest degree of moderate and heavy calculus. While there is little difference in the degree of bone loss in the six cultures, the Paracas Indians showed a somewhat higher degree of loss.

With regard to primary arches and dentitions, the only antemortem tooth losses were one tooth in the maxillae in the Colonial individuals and two teeth lost from the mandibular arches of the those from the Ica culture (Table 4). No first or second molars of either arch were lost in these specimens and there were no congenitally missing teeth. As with the permanent dentitions, the Paracas, Ica and Colonial Indians had the highest incidence of dental caries in both arches (Table 5). Individuals from these three

TABLE 1
Frequency of Missing or Unerupted Teeth in the Permanent Dentitions

CULTURE	N	NTP	M3								
			TEETH LOST		X TEETH LOST PER JAW	NTP	% MISSING	% CONGEN- ITALLY MISSING	% WITH SEMI- OR UNERUPTED	MOLAR 1 %	MOLAR 2 %
			NUMBER	%							
Paracas											
maxillary	46	736	101	13.7	2.2	92	18.5	5.5	17.4	19.6	18.5
mandibular	31	496	64	12.9	2.1	62	19.4	4.9	24.2	35.5	37.1
Nazca											
maxillary	9	144	10	6.9	1.1	18	11.1	0.0	22.2	11.1	16.7
mandibular	20	320	30	9.4	1.5	40	12.5	0.0	10.0	15.0	22.5
Huari											
maxillary	13	208	19	9.1	1.5	26	11.5	0.0	23.1	19.2	15.4
mandibular	14	224	23	10.3	1.6	28	7.1	0.0	3.6	28.6	21.4
Ica											
maxillary	24	384	56	14.6	2.3	48	18.8	2.1	27.1	20.8	33.3
mandibular	25	400	52	13.0	2.1	50	16.0	4.0	24.0	34.0	32.0
Inca											
maxillary	20	320	42	13.1	2.1	40	12.5	0.0	57.7	2.5	2.5
mandibular	19	304	42	13.8	2.2	38	10.5	0.0	47.4	5.3	5.3
Colonial											
maxillary	20	320	33	10.3	1.7	40	10.0	5.0	5.0	17.5	7.5
mandibular	21	336	55	16.4	2.6	42	19.0	4.8	7.1	47.6	35.7
Average											
maxillary	22.0	352.0	43.5	11.28	1.82	44.0	13.73	2.10	25.38	15.12	15.65
mandibular	21.7	346.7	44.3	12.63	2.02	43.3	14.08	2.28	19.38	27.67	25.68

N = number of jaw specimens

NTP = number of teeth possible

X = mean

cultures also showed (Table 6) the highest incidence of osteitis and the highest degree of moderate and heavy calculus. The Paracas culture Indians showed a slightly higher degree of bone loss in the arch than the other cultures, but this difference is not significant.

Discussion

The results indicate that in the permanent dentitions the Paracas, Ica and Colonial individuals have the highest incidence of missing antemortem teeth while in the primary dentitions only the Ica and Colonial cultures have specimens showing tooth loss. The Nazca and Huari permanent dentitions exhibit the lowest incidence of antemortem tooth loss. These findings parallel dental caries incidence, as the Paracas, Ica and Colonial Indians have the highest incidence of dental caries in both the permanent and primary dentitions. The incidence of antemortem tooth loss has been reported to decline spectacularly with the transition to an agricultural society, from

41.6% loss in early hunting and gathering economies to 6.2% in the most recent phases.⁸ These pre-Columbian cultures were primarily agricultural societies. Average tooth loss in the permanent dentitions was 11.3% in the maxillary arch and 12.6% in the mandibular arch. In our earlier study² consisting of 101 mandibles, an 18.6% antemortem loss was found. The tabulated findings on antemortem tooth loss in ten prehistoric adult populations show a 19.9% loss for Gran Canaria.⁹ The Inca individuals showed the highest incidence of semi- or unerupted third molars. This group also had low scores for caries, bone loss, and calculus, suggesting that although the sample was an adult population, it was a younger age group than the other cultures. (This was later confirmed by age analysis.)

The Paracas, Colonial and Ica Indians showed evidence of congenitally missing third molars. The Paracas individuals showed the highest incidence of congenitally missing third molars in both arches,

being 5.5% in the maxillae and 4.9% in the mandible. The Nazca, Huari and Inca Indians showed no specimen with congenitally missing teeth among those studied. The average for all six cultures was 2.1% for the maxillae third molars and 2.3% for the mandibular third molars.

While at least one of the cultures consisted of young adults, the incidence of third molar hypodontia was 15.8% (including those that were congenitally missing) for the maxillary arches and 16.4% (including the congenitally missing) for the mandibular arches. Carbonell¹⁰ reported a 2.6% incidence of third molar hypodontia (mandibles only) in the Kish of Mesopotamia (3000 B.C.) while Crispim et al¹¹ reported 8% per quadrant and 2% for all four third molars in a trihybrid Brazilian population. Niswander¹² reported a 30.5% incidence of one or more missing third molars in the Xavante Indians of Brazil, and Dahlberg¹³ indicated that Mongoloid people have a higher percentage of agenesis of third molars than do other groups. Our earlier data² showed a third molar hypodontia of 3.6% in 101 mandibles. The present

data more clearly confirms what one would expect in a population of Mongoloid background. An obvious difficulty in comparison of available data is the lack of uniformity in reporting results.

Our findings on attrition indicate that the six pre-Columbian cultures had moderate attrition and no resulting pulp exposures. Occlusal wear pattern was not noticeably oblique as noted in cultures where teeth are used to strip husk or bark from a food source. It would appear that the cultures shared a similar diet in terms of consistency and/or preparation. Previous reports^{3,4} on pre-Columbian Peruvians also found no severe attrition or pulp involvement. Similarly, Carbonell¹⁴ found no pulp involvement from attrition in ancient Mesopotamians. Although the data on partially erupted third molars suggest that the Inca specimens are of a younger age, these individuals still had attrition effects similar to the specimens of the other cultures.

Results of dental caries have meaning only when comparisons are made among the cultures observed. While lower age may cause the low caries in the Inca

TABLE 2
Frequency and Severity of Attrition and Dental Caries in the Permanent Dentitions

CULTURE	N	X SCORE OF ATTRITION 0, 1, 2, 3	TNT	CARIES BASED ON DMFS		CARIES BASED ON DS	
				X DMFS/TOOTH	X DMFS/JAW	X DS/TOOTH	X DS/JAW
Paracas							
maxillary	45	1.8	434	2.23	19.20	1.08	8.02
mandibular	30	1.9	362	2.30	22.90	1.16	11.50
Nazca							
maxillary	9	2.1	102	1.02	11.56	0.43	4.89
mandibular	20	2.2	264	1.03	13.65	0.47	6.15
Huari							
maxillary	13	1.6	142	1.37	15.00	0.70	7.69
mandibular	14	1.9	174	1.25	10.79	0.59	7.36
Inca							
maxillary	24	1.9	294	1.96	24.04	1.01	12.38
mandibular	25	2.2	296	1.97	21.72	1.01	11.32
Inca							
maxillary	20	1.8	316	0.22	3.55	0.03	0.55
mandibular	19	1.9	302	0.24	3.74	0.04	0.58
Colonial							
maxillary	20	2.1	295	1.66	24.45	1.15	16.95
mandibular	21	2.1	306	1.82	26.48	0.87	12.67
Average							
maxillary	15.2	1.88	263.8	1.410	16.300	0.733	8.413
mandibular	21.5	2.03	284.0	1.435	16.547	0.690	8.263

N = number of jaw specimens

TNT = total number of teeth

X = mean

DMFS = decayed, missing, filled tooth surfaces

DS = decayed surfaces

TABLE 3
Frequency and Severity of Osteitis, Calculus and Bone Loss in the Permanent Dentitions

CULTURE	OSTEITIS		CALCULUS % AFFECTED			BONE LOSS		
	N	% AFFECTED	N	LIGHT	MODERATE	HEAVY	N	X SCORE 0,1,2,3
Paracas								
maxillary	46	32.6	45	30.0	50.0	20.0	46	1.8
mandibular	31	38.7	30	23.3	50.0	26.7	31	2.0
Nazca								
maxillary	9	44.4	9	87.5	12.5	0.0	9	1.7
mandibular	20	45.0	20	83.3	5.6	11.1	20	1.5
Huari								
maxillary	13	15.3	13	83.4	16.6	0.0	13	1.1
mandibular	14	14.2	14	83.4	8.3	8.3	14	1.2
Ica								
maxillary	24	16.7	24	33.3	44.5	22.2	24	1.3
mandibular	25	20.0	25	35.0	40.0	25.0	25	1.3
Inca								
maxillary	20	33.0	20	33.3	66.7	0.0	20	1.2
mandibular	19	50.0	19	50.0	50.0	0.0	19	1.3
Colonial								
maxillary	20	20.0	20	40.0	40.0	20.0	20	1.4
mandibular	21	23.8	21	57.0	21.5	21.5	21	1.3
Average								
maxillary	22.0	27.00	15.2	51.25	38.38	10.37	22.0	1.42
mandibular	21.7	31.95	21.5	55.34	29.23	15.43	21.7	1.43

N = number of jaw specimens

X = mean

TABLE 4
Frequency of Missing or Unerupted Teeth in the Primary Dentitions

CULTURE	N	NTP	TEETH LOST		X TEETH LOST PER JAW	% CONGENITALLY MISSING	MOLAR 1	MOLAR 2
			NUMBER	%			LACKING	LACKING
Paracas								
maxillary	9	90	0	0.0	0.0	0.0	0.0	0.0
mandibular	6	60	0	0.0	0.0	0.0	0.0	0.0
Nazca								
maxillary	2	20	0	0.0	0.0	0.0	0.0	0.0
mandibular	2	20	0	0.0	0.0	0.0	0.0	0.0
Huari								
maxillary	4	40	0	0.0	0.0	0.0	0.0	0.0
mandibular	3	30	0	0.0	0.0	0.0	0.0	0.0
Ica								
maxillary	14	140	0	0.0	0.0	0.0	0.0	0.0
mandibular	15	150	2	1.3	0.13	0.0	0.0	0.0
Inca								
maxillary	2	20	0	0.0	0.0	0.0	0.0	0.0
mandibular	3	30	0	0.0	0.0	0.0	0.0	0.0
Colonial								
maxillary	15	150	1	0.7	0.06	0.0	0.0	0.0
mandibular	16	160	0	0.0	0.0	0.0	0.0	0.0
Average								
maxillary	7.7	76.7	0.16	0.12	0.01	0.0	0.0	0.0
mandibular	7.5	75.0	0.33	0.22	0.02	0.0	0.0	0.0

N = number of jaw specimens

NTP = number of teeth possible

X = mean

TABLE 5
Frequency and Severity of Attrition and Dental Caries in the Primary Dentitions

CULTURE	N	X SCORE OF ATTRITION 0,1,2,3	TNT	CARIES BASED ON DMFS		CARIES BASED ON DS	
				X DMFS/TOOTH	X DMFS/JAW	X DS/TOOTH	X DS/JAW
Paracas							
maxillary	9	1.5	76	0.49	4.1	0.49	4.1
mandibular	6	1.3	54	0.35	3.2	0.35	3.6
Nazca							
maxillary	2	1.3	19	0.21	2.0	0.21	2.0
mandibular	—	—	—	—	—	—	—
Huari							
maxillary	4	1.5	34	0.47	4.0	0.47	4.0
mandibular	3	1.6	24	0.17	1.3	0.17	1.3
Ica							
maxillary	14	1.7	105	0.47	3.5	0.47	3.5
mandibular	15	1.6	123	0.33	2.7	0.25	2.1
Inca							
maxillary	2	1.0	10	0.10	0.5	0.10	0.5
mandibular	3	0.8	28	0.00	0.0	0.00	0.0
Colonial							
maxillary	15	1.2	115	0.55	4.2	0.50	3.9
mandibular	16	1.1	128	0.36	2.9	0.36	2.9
Average							
maxillary	7.7	1.37	59.8	0.382	3.05	0.373	3.00
mandibular	8.6	1.28	71.4	0.242	2.02	0.226	1.98

N = number of jaw specimens

TNT = total number of teeth

X = mean

DMFS = decayed, missing, filled tooth surfaces

DS = decayed surfaces

Indians, the reasons for different caries incidence in the remaining groups are not as obvious. The three groups scoring high on caries also scored highest in calculus involvement. The Paracas, Ica and Colonial individuals who had the highest caries incidence were all members of "coastal" as opposed to "inland" cultures. Something in the diet or water of the "inland" people, such as fluoride, could have protected them against caries. Further investigation on fluoride content of bones and teeth should shed some light on this relationship. The reason for a lower incidence of caries in the Nazca individuals, also a "coastal" group, is not readily apparent.

The maxillae are more frequently involved with caries than the mandible.¹⁵ In the present study this was noted using both the incidence of caries based on DMFS and on DS in primary dentitions. The maxillae were shown to be more frequently involved with caries using the DS index in the permanent dentitions, but because of the large number of missing teeth (antemortem) in the mandibles of the per-

manent dentitions, the DMFS showed the incidence of caries to be about equal in the two arches. Because of the method of scoring using the DMFS index, this can be considered a misleading value and again the maxillae showed a higher incidence of caries. In this study, using optimal gross examination coupled with roentgenographic analysis, 26.7% of the individuals with primary dentitions and 85.2% of the individuals with permanent dentitions had one or more carious lesions. In our earlier study² 70% of the permanent mandibles had one or more carious lesions. Leigh⁴ reported a 35% incidence in specimens having both jaws. Although the reason is still not evident, the high incidence of caries has now been shown to be consistent in our two studies and in fact increased because of the inclusion in this present study of maxillae having a higher incidence of dental caries. The caries incidence in the combined adult population in the United States as of 1962 was 20.4 DMFS teeth per person.¹⁶ The overall average of DMFS per specimen in our earlier pre-Columbian study² was 13.76 in 101

TABLE 6
Frequency and Severity of Osteitis, Calculus and Bone Loss in the Primary Dentitions

CULTURE	OSTEITIS		CALCULUS % AFFECTED			BONE LOSS		
	N	% AFFECTED	N	LIGHT	MODERATE	HEAVY	N	X SCORE 0,1,2,3
Paracas								
maxillary	9	11.1	9	37.5	50.0	12.5	9	1.5
mandibular	6	16.7	6	40.0	40.0	20.0	6	1.7
Nazca								
maxillary	2	0.0	2	50.0	50.0	0.0	2	1.5
mandibular	2	0.0	—	—	—	—	2	1.5
Huari								
maxillary	4	0.0	4	66.7	33.3	0.0	4	1.0
mandibular	3	0.0	3	50.0	50.0	0.0	3	1.2
Ica								
maxillary	14	7.1	14	46.2	46.2	7.6	14	1.2
mandibular	15	6.7	15	50.0	35.7	14.3	15	1.1
Inca								
maxillary	2	0.0	2	50.0	50.0	0.0	2	1.2
mandibular	3	0.0	3	66.7	33.3	0.0	3	1.3
Colonial								
maxillary	15	6.7	15	6.7	93.3	0.0	15	1.3
mandibular	16	12.5	16	12.5	87.5	0.0	16	1.4
Average								
maxillary	7.7	4.15	7.7	42.85	53.80	3.35	7.7	1.27
mandibular	7.5	5.98	8.6	43.84	49.30	6.86	7.5	1.37

N = number of jaw specimens

X = mean

permanent mandibles. In the present study the average DMFS was 16.3 per maxillary specimen and 16.5 per mandibular specimen. The higher DMFS per specimen in the present study as compared to our earlier work is no doubt related to the use of the x-ray unit. While these figures do not correspond exactly with those in the United States as of 1962, they are similar, as to incidence of caries, to the present study. Caries data on present day Peruvians are not available for comparison.

Osteitis was noted in all six cultures. The Nazca and Inca showed the highest incidence in the arches with permanent dentitions while the Paracas, Ica and Colonial individuals had the highest incidence in the primary. This finding paralleled the findings on the mean number of missing antemortem teeth while calculus accumulation appeared to relate directly to caries incidence.

The amount of alveolar bone loss was moderate among individuals from all cultures with those from the Paracas culture leading the way. Bone loss did not correlate directly with calculus or caries scores. It is plausible that a less refined and abrasive diet caused both moderate attrition and alveolar bone loss in all cultures irrespective of age.

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