THE UNIVERSITY OF CALGARY

Health at the North Coast Site of Puemape During the Peruvian Formative Period

by

Robert Milan Gillespie

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Abstract:

This thesis considers the health of three populations that lived on the North Coast of Peru during the Initial Period and Early Horizon. They lived on the littoral zone south of the mouth of the Jequetepeque River. These populations were from the Early and Classic phases of the Cupisnique cultural complex and the Salinar culture. Their cultural lifetimes were 1,200 to 900, 900 to 500 and 400 to 100 B.C., respectively. There was major tectonic activity from 1,500 to 1,000 B.C., possibly a tsunami at ~800 B.C. and severe El Niño activity just prior to the Salinar cultural period. Classic and Late Cupisnique phases are contemporaneous with the Chavín cult, which unified the North Coast and Highlands. Salinar culture arose after the disintegration of the Chavín cult. The evidence suggests that the frequency of dental caries, dental abscesses and fractures increased with time while dental attrition and life expectancy decreased.

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There are a great number of people that have made this exercise possible and successful.

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This thesis is dedicated to the past peoples of Puémape. They may not have understood the point of this study but I hope they would not be offended by the intrusion into their lives.

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Chapter 1 - **Introduction**

Background to the Study

This thesis considers the health of three populations that lived on the North Coast of Peru between 1,500 B.C. and 100 B.C. These populations lived at Puémape, a site on the littoral zone south of the mouth of the Jequetepeque River at the mouth of the Cupisnique valley. The Jequetepeque is one of twelve major drainages along the North Coast of Peru (see Figure 1.1 for a map of this region). The North Coast is bounded to the north by the Sechura Desert, to the west by the Pacific Ocean, to the south by the mountains that reach the Pacific Ocean south of the Casma valley and to the east by the foothills of the Andes (Shimada, 1994). Figure 1.2 shows the river mouth region and the location of the site at Puémape. Note the outline of the limits of agriculture drawn by Kroeber. He described the river mouth region as follows (Kroeber, 1926: 86,87).

> "The valley of Jequetepeque has three parts. The middle portion lies along the river, is rather narrow, and with its mixture of sand dunes, palms, and fertile spots is in places reminiscent of the Ica, hundreds of miles to the south. A second portion lies to the south, toward and around San Pedro de Lloc, and is watered by acequias that leave the river toward the left. ... The third portion of the valley also lies off the river, but to the north, about Chepen, Guadalupe, and Pueblo Nuevo. The last named is on the Rio Seco de San Gregorio; Chepen and Guadalupe are rather nearer to that stream bed than to the Jequetepeque; but the water supply of the whole tract seems to derive itself from the Jequetepeque. The Guadalupe sector is said to produce more today than the Jequetepeque one; but the most important ancient sites are in the middle sector near the natural mouth of the river."

The site of Puémape is within the second portion, to the south of the river and on the north side of the Cupisnique drainage. The Jequetepeque River valley is the second largest drainage on the North Coast, has the third largest area of cultivated land and has one of the largest spreads between maximum and minimum flow rates on the North Coast (reviewed in Shimada, 1994). Keatinge (1980) noted that this valley is one of the most important agricultural zones in Peru. It is also known for periodic droughts that greatly reduce productivity. The climatic regime of this region has been stable for as long as there has been a human presence in this region (reviewed in Parsons, 1970).

The archaeological excavations at Puémape were carried out between February and September, 1990, under the direction of Carlos Elera and José Pinilla. Their excavations were under the auspices of the Office of Research of the Museo de la Nación, Lima, Peru (Carlos Elera, personal communication). An exhibit at the Museo de la Nación was completed in 1992 featuring this site. The excavation revealed the presence of the Cupisnique cultural complex and the Salinar culture from the Peruvian Formative Period (Elera, *et al.*, 1992). Another chronology, used in this thesis, is from Burger (1992) and places the Cupisnique cultural complex in the Initial Period, the Salinar culture in the Early Horizon. The Cupisnique cultural complex has been further subdivided into Early, Classic or Middle and Late phases. The skeletal series examined as part of this study were from the Early and Classic Cupisnique phases and the Salinar culture. The Late Cupisnique phase was very short, less than a century, (Elera, 1992) and no skeletal remains were excavated from this period.

Figure 1.1 - Map of North Coast of Peru

(from Strong and Evans, 1952)

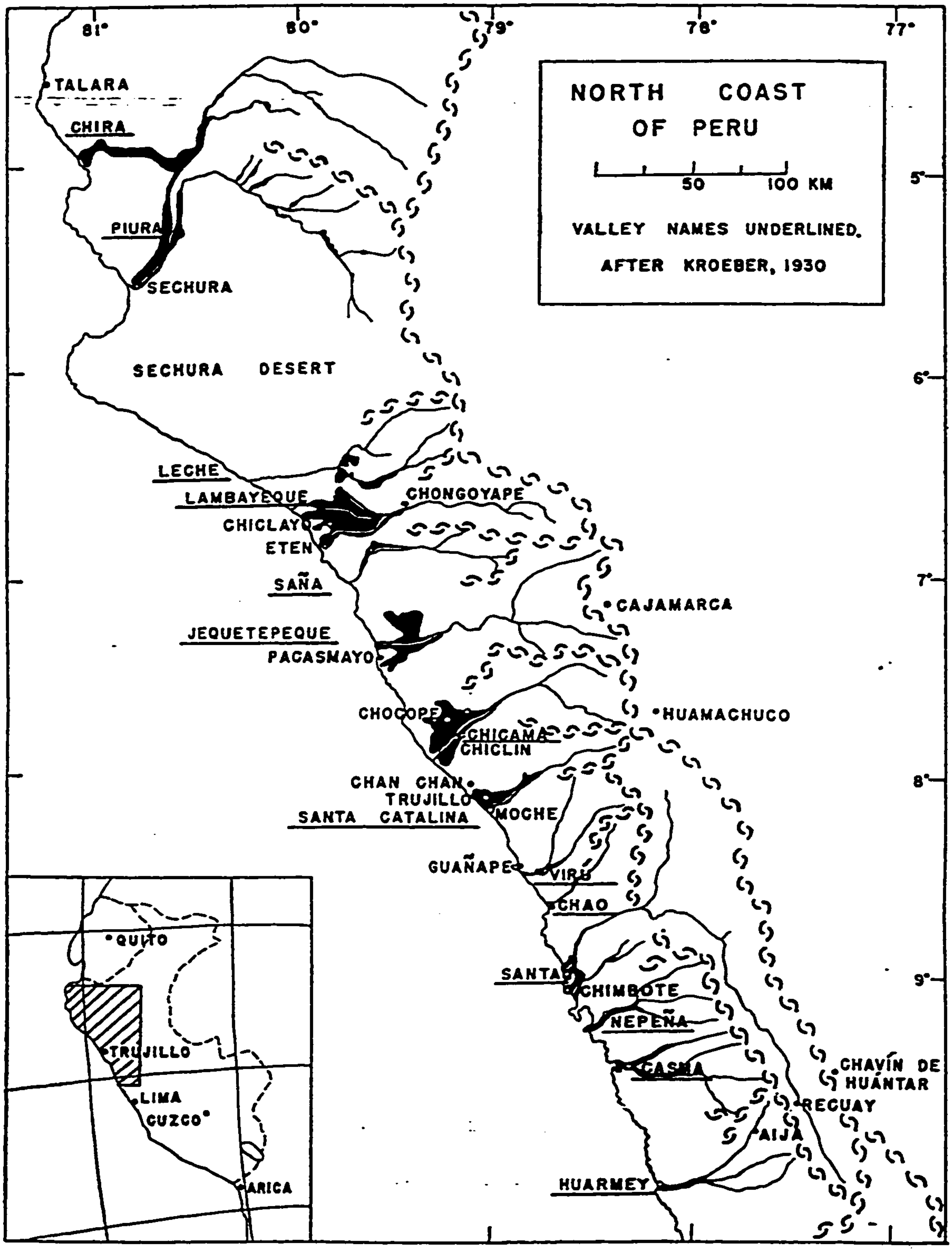
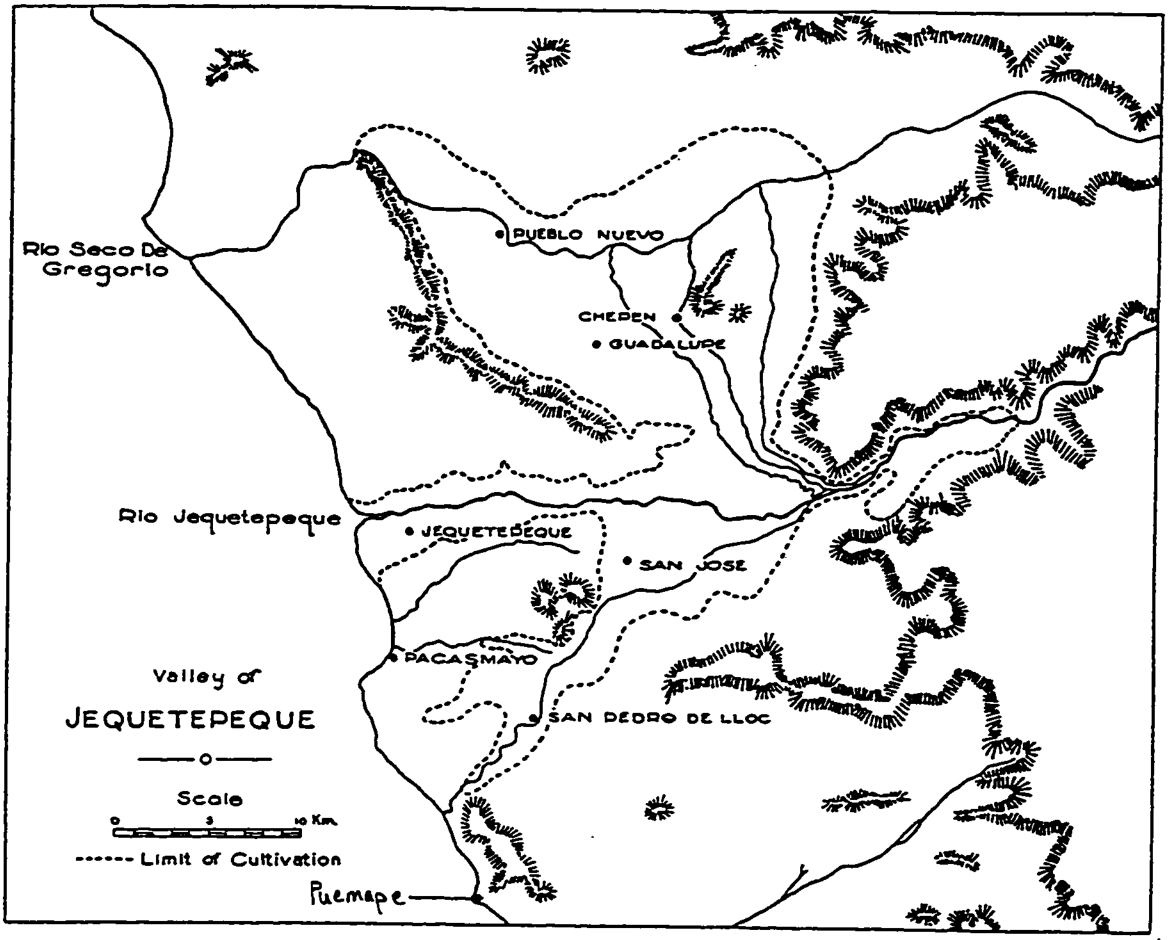


Figure 1.2 - Map of Lower Jequetepeque Valley and Location of Puémape

(From Strong and Evans, 1952)

Puémape is located near the bottom of the map.



Questions for Consideration

The basic question to be asked is: how effective was each population's adaptation to the changing environment? Equally relevant is the question of how the political climate of each society affected the health of its subjects. If any of the populations from Puémape demonstrate significant differences from the other populations, cultural and environmental factors will be considered to provide an explanation for these findings. As well, these patterns of adaptation can be compared with patterns in other regions to measure the relative success of their adaptation.

Questions to be asked include the following:

1. How does the growth trajectory of these populations, as indicated by the relationship between long bone and dental development, compare to that of recent populations? These Peruvian populations will be compared with recent English infants (Scheuer *et al.*, 1980) or recent Euro-american infants and children (Gindhart, 1973). These populations were chosen as examples of recent populations for which the desired information is present. They will also be compared with a proto-historic North American Native population, the Arikara (Ubelaker, 1989). This population was chosen as representative of Native American peoples. The growth trajectory of the Arikara population is expected to be similar to that of the populations from Puémape. Similarly, the populations at Puémape are expected to show identical growth rates. Evidence for growth retardation in any of the populations from Puémape will

be evaluated in the light of environmental conditions and cultural change.

2. Are Harris lines more closely correlated with periods of rapid growth than with episodic stress? Magennis (1990) argued for this model of Harris line development. Allison *et al.* (1975), followed the standard view that Harris lines follow growth cessation due to disease or nutritional inadequacy. They pointed to apparently healthier Andean peoples than coastal peoples based upon their lower frequency of Harris lines. If overall growth rate was the only factor in the development of Harris lines then the coastal people may simply have had higher growth rates than the highland peoples. Differences in growth rate between highlanders and coastal peoples have been observed by Frisancho and Spielman (1972). I will also consider some of the pitfalls in interpreting Harris lines as reviewed in Larsen (1987) and considered in papers by Grolleau-Raoux *et al.* (1997) and Macchiarelli *et al.* (1994). Significant differences in Harris line frequency between populations would indicate perturbations in growth according to either model of Harris line development. If such variation is evident, cultural and environmental factors will be considered to postulate instigating factors.
3. What does the frequency of porotic hyperostosis tell about health and subsistence in these populations? The Cupisnique cultural complex predated and was contemporaneous with the Chavín cult while the Salinar culture followed the Chavín cult and preceded the Moche culture, which is the classic culture of the Early Intermediate Period on the North Coast (Bawden, 1995). All of these cultures are known from the archaeological evidence to have

used marine and terrestrial resources. Terrestrial resources were both native and introduced species some of which may have been obtained by trade from villages farther up the river valley (Burger, 1992). Porotic hyperostosis represents an iron deficiency of varying etiology (Mensforth et al. 1978; Kent, 1980; Stuart-Macadam, 1987a; Ubelaker, 1990; Walker, 1986) and the frequency of this disorder in these populations will be related to the models for its development.

4. Does the frequency of disease affecting the skeleton differ from that found in populations in Ecuador? Differences are expected to be due to differing subsistence bases, population density and cultural factors (such as extent of long distance trade). Ubelaker, in a series of papers (1980a, 1980b, 1983) described paleopathology for Ecuadorian populations, both coastal and highland. These populations will be used for comparison since no analysis of paleopathology has previously been conducted with complete skeletons from the North Coast of Peru. The first of these studies by Ubelaker (1980a) considered an Ecuadorian coastal population from the Sta. Elena Peninsula dating to 6,000 B.C. This population preceded the Cupisnique cultural complex, while the second study by Ubelaker (1980b) concerned highland Ecuadorian populations (at the site of Cotocollao) contemporary with Early and Classic Cupisnique phases (1100 and 540 B.C.). The population from the Guangala site (Ubelaker, 1983) was contemporary with the latter part of the Salinar culture (100 B.C.).

5. What is the frequency of arthritides in these populations? Do all three

populations have the same types in the same frequencies? Arthritis in these populations will be compared with the populations studied by Ubelaker (1980a, 1980b, 1983), as well as other prehistoric New World populations (Cybulski, 1990, 1992, 1994; also reviewed in Bridges, 1992; Jurmain and Kilgore, 1995). Patterns of osteoarthrosis are believed to represent changes in habitual behaviours (Bridges, 1992) and these should parallel archaeological evidence for changes in subsistence which follow the requirements of environmental changes and cultural developments.

6. Can all pathological conditions evident in populations from Puémape be identified as representing a disorder known in modern populations? If not, are models describing the etiology of novel disease processes applicable? Models to be considered are those of Klepinger (1980) and Mims (1980). The reasoning for this question will be outlined in Chapter 5.
7. Is dental attrition correlated to archaeological evidence for subsistence? Carlos Elera (personal communication) indicated that subsistence shifted from being primarily marine based (particularly molluscs) during the Cupisnique cultural complex to terrestrial fruits and tubers during the Salinar culture. This suggests that dental attrition should be less since there will be less sand in food.

Chapter Summary

This chapter (Chapter 1) serves as an introduction to the site at Puémape and to the North Coast of Peru. As well, the populations to be studied have been introduced. Next was an outline of the types of information to be gleaned from these populations. This last section outlines the contents of each chapter.

The second chapter will be a review of physical anthropology research conducted on prehistoric Peruvian populations. As well, Chilean and Ecuadorian populations will be considered for comparative purposes.

Chapter 3 will be a review of the pertinent archaeology of the Initial Period and Early Horizon. This will focus on archaeological evidence for subsistence patterns, political and ideological structure and the pattern of population settlement during this time.

Chapter 4 will outline the results of this study. This will include the age and sex structure of the sample populations. Infant and childhood growth will be considered. Also to be presented will be the assessment for visual and radiographic evidence of Harris lines, porotic hyperostosis, systemic illness such as cancer and infection, arthritic processes, trauma and dental disease and attrition.

Chapter 5 will be a discussion of these results with respect to the cultural and environmental context of the populations. There will also be comparisons with coastal and highland peoples of Ecuador, Peru and Chile as well as comparisons with Northwest Coast North American populations.

Chapter 6 will summarize the answers to the questions in this chapter (Chapter 1).

Chapter 2 - **Physical Anthropology of the Prehistoric People of Peru**

Introduction

A feature of many studies of Peruvian prehistory has been the relative paucity of research in physical anthropology. Shimada (1991), in the introduction to his book, gave two examples of this. For the region surrounding Pachacamac he reported that the latest skeletal assessment published in the English language was in 1947 by Newman. There has been a small amount of research published in Spanish with a focus on craniometry, and more recently infracranial remains have been considered as well (Paredes and Franco, 1984).

The other example given in Shimada (1991) is a sample of 2500 burials exhumed in the 1940's at Ancon. These burials had not been described, even in the archaeological literature. This is curious since so much has been written about Peruvian prehistory based upon archaeological excavations and interpretations. Certainly archaeological interpretations can be placed on more firm footing if the diachronic and synchronic biological relationships among peoples are understood and if subsistence strategies can be supported by chemical analysis. Table 2.1 (from Burger, 1992: 230, 231) provides an outline of the cultural chronology of the Peruvian Andes.

Table 2.1 - Andean Cultural Chronology

(From Burger, 1992)

The column headings refer to highland regions or river valleys. This first chart deals with southern Ecuador and the northern half of Peru.

Time Scale	Guayas Basin	Pacopampa	Bagua & Jaen	Cajamarca	Huamachuco	Moche & Chicama	Viru	Casma	Supe	Period / Horizon
A.D. / B.C.	GUANGALA		EL SALADO TARDIO			GALLINAZO	GALLINAZO			
200				LAYZÓN	SAUSAGOCHA	SALINAR	PUERTO MOORIN	Chankillo	WHITE-on-RED	
400		PACOPAMPA CHAVIN	EL SALADO	EL	PELON	Huaca de los Chinos		San Diego	Chimu Capac	Early Horizon
600	CHORRERA		LA PECA				LATE GUAÑAPE			
800										
1000			BAGUA II	LATE HUACALOMA	COLPA	CUPISNIQUE	MIDDLE GUAÑAPE	Las Haldas	Bermejo	
1200	MACHALILLA	PACOPAMPA PACOPAMPA						Moxeke		
1400										Initial Period
1600	VIII		BAGUA I	EARLY HUACALOMA		Montegrande			La Empedrada	
1800		PANDANCHE A					EARLY GUAÑAPE	Tortugas		
2000	VII									
2200										
2400	VALDIVIA VI					Huaca Prieta	CERRO PRIETO	Huaynuná		
2600	V								Aspero	Late Preceramic Period
2800	IV III									
3000	II									

Table 2.1 continued

This second chart deals with the southern half of Peru.

Time Scale	Mosna	Callejón de Huaylas	Upper Huallaga	Central Ucayali	Rimac & Lurin	Paracas & Ica	Ayacucho	Cuzco	Lake Titicaca Basin	Period / Horizon
A.D. / B.C.				HUPA - IYA			RANCHA			
200	HUARÁS	HUARÁS	SAJARA-PATAC		BAÑOS DE BOZA	OCUCAJE 7-10	CHUPAS	DERIVED CHANAPATA	PUCARA	Early Horizon
400	JANABARRIU	LATE CAPIILLA	KOTOSH CHAVIN	LATE SHAKIMU	Ancón	OCUCAJE 3-6	KISHKAPATA		LATE CHIRIPA	
600	CHAKINANI	EARLY CAPIILLA					WICHQANA	CHANAPATA	MIDDLE CHIRIPA	
800	URABARRIU			EARLY SHAKIMU		Disco Verde		A		
1000		HUARICOTO	KOTOSH-KOTOSH	LATE TUTISHCAINYO	Cardal / Garagay			MARCAVALLE B C	LATE QALUYU	
1200								D		
1400						Erizo			EARLY QALUYU	Initial Period
1600		TORIL	WAIRA-JIRCA							
1800				EARLY TUTISHCAINYO	La Florida					
2000					El Paraiso					
2200		CHAUKAYAN	MITO		Ventanilla					
2400							CACHI			Late Preceramic Period
2600										
2800										
3000										

This review will consider skeletal material from the coastal regions of the present day nations of Peru, northern Chile and southern Ecuador. The focus of this chapter will be post 1950, as this period saw the maturing of physical anthropology beyond cranial measurement to include study of the infracranial skeleton. As well, the implementation of sophisticated chemical strategies of analyses began during this time. The application of these methods allowed researchers to test hypotheses generated by archaeological interpretations of subsistence, demography, population movement and interpopulation biological relationships.

This review will present material sequentially from the cranium inferiorly. The reasons for this are as follows. This is as an easily understood direction of movement during analysis, but it also echoes the chronological trend in human skeletal studies. The papers included will be dealt with as a whole, therefore, a subject such as porotic hyperostosis will be reviewed in the papers dealing with population health as there are no studies dealing with this lesion only. Aspects of prehistoric burial practice will be considered, where appropriate, however this topic will not be formally addressed.

Paleopathology

Studies of Cranial Material

Trephination

Interest in cranial features, including discussion of trephination, has a long history (Ackerknecht, 1947). This procedure was not uncommon with examples having been dated between 700 A.D. to the early 1900's in Peru, with associated mortality rates reported in Ackerknecht (1947) to be less than or equal to 50%. Vreeland and Cockburn (1983) indicated that half of the trephined skulls known worldwide are from Peru. Lisowski (1967) reviewed the methodology and cultural reasoning behind this procedure.

Cranial Deformation

Another aspect of cranial research is that involving cranial deformation. Muñizaga (1969) discussed cranial features in two phases of the prehistory of Ecuador. These are the coastal Valdivia and the highland Machalilla phases. Valdivia phase crania were assigned to that phase based upon occipital flattening. Although sample sizes were small, there were differences between the Valdivia population and coexisting Peruvian populations. This suggested to Muñizaga that these two groups descended from different ancestral populations. He argued that cranial deformation, as a coastal phenomenon, began 4,000 years ago in Ecuador and diffused southward to influence Paracas culture and the Cupisnique cultural complex.

Newman (1947) considered cranial features for peoples inhabiting the central coast of Peru. His sample included material from Early, Middle and Late Periods and totaled 231 adult crania. These corresponded to Interlocking Style Incised, Epigonal and Chancay ceramic styles. He analyzed the extent and type of cranial deformation, pathology and metric and non-metric traits. His goal was to determine the classic skull shape for the region and reveal the degree of relatedness of each population. He concluded that cranial deformation decreased with time and that population relationships were not easy to discern. However, he believed that over time there was increasing relatedness between peoples from different valleys as populations increased. Pathological changes observed included involvement of the cranial and infracranial skeleton. These included a variety of cranial, long bone and rib fractures, congenital malformations and evidence of osteoarthrosis. Other lesions found throughout the skeleton were interpreted as representing osteomyelitis.

Carmichael (1988) in his dissertation on Nasca burial customs noted cranial deformation. He observed much variation in cranial shape but felt that earlier reports of Nasca burials had exaggerated its prevalence. He considered its occurrence comparable in both sexes and in all status levels in the Early Intermediate Period. This agreed, in part, with de las Casas (cited in Buikstra, 1995) who stated that cranial deformation was an ethnic phenomenon used to identify the province of origin of people. All Nasca people with cranial deformation, by this criterion, would have the same type and it would be present in all levels of society.

Craniometry

Ericksen (1962) used metric analysis of crania from the northern highlands of Peru to build on previous analyses for South Coast peoples. She noted differences between North Coast crania and those from the south in terms of their vault and cranial heights for the period represented by Cajamarca I and II ceramics. Cajamarca IV crania were demonstrably less distinct and she concurred with Newman that this had to do with increased gene flow between populations during a time when the populations were linked politically.

Rothhammer *et al.* (1982, 1984) considered metric and non-metric traits for populations from the archaic period (5470 B.C.) to the late agricultural period (1100-1300 A.D.) from northern Chile. Despite small sample sizes they were able to demonstrate that both means of analysis revealed a diachronic trend in cranial shape. They were also able to show closer relationships between males and females for each period than between periods. Ultimately, with larger sample sizes and the addition of genetic data they hoped to be able to trace population and gene movement over time.

External Auditory Exostoses

Exostoses of the external auditory meatus have been described in skeletal remains from both preceramic and ceramic populations from Huaca Prieta, Peru. Tattersall (1985) revealed that the frequency was considerably higher in males than females (86% versus 16% for the preceramic period). In the ceramic period 50% of males and 20% of females had exostoses. There was also a correlation with age, the older individuals tending to have more severe exostoses. The development of these exostoses may be correlated with exposure to cold water either by swimming or by exposure to mist from cold surf (Hutchinson *et al.*, 1997). This gave some indication of resource utilization at this site and correlated with the marine faunal remains at the site. The faunal remains included bivalves such as mussels and fish caught by fishing with nets in heavy surf.

One confounding factor is that auditory exostoses may be present in individuals not chronically exposed to cold water. Hutchinson *et al.* (1997) indicated the variety of skin conditions and environmental conditions believed to lead to the development of these exostoses. They stated that "Our research indicates that it is unlikely...that cold water can serve as an exclusive etiology for auditory exostoses" (Hutchinson *et al.*, 1997: 421). The relationship may be better understood when other populations are considered for this trait.

One such study was that by Standen et al. (1997) who considered northern Chilean peoples from 7,000 B.C. to 1500 A.D. They found that coastal people had the highest levels of external auditory exostoses (30.7%) followed by mid valley peoples (2.3%) with the lowest frequency in the highlands (0%). They found an interesting diachronic trend in which the frequency of external auditory exostoses in coastal peoples increased over time. This was despite an increasingly agrarian lifestyle. Standen *et al.* (1997) argued that they were harvesting the marine resources for trade to upper valley people.

Other relevant Chilean material comes from the northern Atacama coast area, and includes mummies in which Allison (1985) found a number of skeletal lesions. These included external auditory exostoses in 25% of males.

Dentition

Scott (1979) studied tooth size among prehistoric coastal Peruvians. Increased dental size was evident between 10,000 B.P. and 1,000 B.P. and increased overall body size was posited as an explanation. There have been no studies, however, to support the premise of increased body size over time. Population affinity studies with non-metric traits or genetic tests may help to explain these results. An increase in caries frequency over time was also observed in his sample. This supports other lines of evidence suggesting increased use of agricultural products throughout Peruvian prehistory. This is because dependence on a diet rich in starchy plant material is more cariogenic than a more diverse diet.

In reviewing burials in the Moche valley, Donnan and Mackey (1978) noted obvious pathology of the interred skeletons. They observed a range of normal human skeletal variants as well as evidence of arthritic processes, trauma, infectious disease, dental caries, dental attrition and intentional modification. Since this was a descriptive report their data was not presented in a standardized manner that would allow comparison with other populations. The only association possible, although tenuous given the detail of the descriptions, was of increased dental caries in Moche Phase IV.

Studies of the Infracranial Skeleton

Harris lines

Harris lines have been studied in a number of populations. Allison, Mendoza and Pezzia (1970) studied tibias from skeletal and mummified remains from the Ica valley. They considered the following cultural groups: Paracas; Nazca; Tiahuanaco and Inka. Tiahuanaco and Inka represented the mountain cultures. They also X-rayed individuals from a modern population at Ica. Their conclusions were that peoples from highland regions had fewer Harris lines than coastal peoples and that modern day peoples have approximately the same frequency of Harris lines as people during Inka times. Also the percentage of lines forming by the eighth birthday was lowest in the Inkas and moderns. This suggested to these authors that there were better weaning foods and better overall health in childhood.

Parturition Scars

Evidence of parturition is of interest to palaeodemographers and a skeletal feature suggestive of parturition is scarring on the posterior aspect of the pubic bones at the pubic symphysis. Ashworth *et al.* (1976) considered the frequency of this feature in pre-Columbian and colonial women. The prevalence was 72.3% in pre-Columbians and 57.6% in colonial women. The percentage for pre-Columbian women was the highest reported in the literature. An argument could be made for a genetic factor in this disorder although age at first delivery and number of deliveries have also been implicated. Ashworth *et al.* (1976) indicated that it was difficult to determine which was most important in the development of these scars and that further study was required.

Studies of Mummified Human Remains

Protein and Genetic Studies

Mummies have been collected representing all of the major cultures in Peruvian prehistory, although the coastal cultures are better represented. Sufficient numbers of well preserved mummies exist to allow direct comparison of peoples from different cultural affiliations at a very sophisticated level. The amount and quality of data to be obtained would considerably aid archaeological interpretation and understanding of human biology.

Allison (1985) and Schobinger (1991) indicated that excellent preservation was not uncommon in the Peruvian and Chilean highlands and coastal deserts. Allison described the Chinchorro mummy complex of the Arica Valley, Chile. The mummification procedures vary, but most involved some level of human intervention. Rivera (1995) reviewed the mummification process for Chinchorro peoples giving four types of mummification. These included natural (Type I), artificial (Type II), which was the most complex and may involve the removal of the internal organs and some skeletal elements. Type III was a simplified version of Type II with less body modification. Type IV, which involved fire drying of the body only, is a simplified Type III, the fire drying being the first stage in Type III mummification. Generally, the more human intervention, the less information was preserved, since in a Type II mummy there may be little of the original body retained. Despite this, information is present. Rivera (1995) reported that craniometric analysis suggested that Chinchorro peoples were closely related biologically to peoples in "the eastern tropical lowlands" (Rivera, 1995: 65).

Schobinger (1991) described mummies found in the high Andes that are natural and that have all tissues well preserved. Besides radiographic evaluation, which is commonly used with mummies, there have been liver, stomach and bowel content studies.

One area of research that has received considerable attention was the determination of blood type in mummified remains. Allison *et al.* (1974, 1978) compared results of various techniques and indicated that the results are reliable. Interestingly, there was a trend from north to south from the Ica drainage to the Nazca, to Arequipa and Tarapaca, of diminishing frequency of blood types A, B and AB and increasing levels of type O. The second study (1978) reinforced this finding using a number of controls to avoid erroneous typing. This study also correlated the results to two theories regarding the indigenous populations. One suggested that there was selection against the A, B and AB genotypes. The other followed the archaeological theory that the Preceramic Chilean population was distinct from Peruvian populations as suggested by differences in frequencies of blood types.

Llop and Rothhammer (1988) reviewed the literature of blood typing of mummies and introduced further results to clarify the discussion. Their results bolstered the thesis that blood types A and B were present prehistorically, although in low frequencies, and that the results of previous studies were accurate.

Carrying these procedures one step further it has become commonplace to consider the genetic material directly without resorting to the gene products, such as blood type. Examples relevant to Peruvian studies include the following studies. Lawlor *et al.* (1991) reported the Human Lymphocyte Antigen haplotype of an individual 7,500 years dead from the Windover site in Florida. This suggests that much of Peruvian prehistory is within the reach of these techniques given the excellent preservation of soft tissue and skeletal materials.

Salvo *et al.* (1989) reported on initial steps in DNA sequencing of a number of nuclear genes for up to 1,000 mummies from northern Chile. Their purpose was to decipher the genetic relationships between prehistoric populations to better understand migration and kinship systems, and perhaps locate genes relevant to disease expression or pathology.

Golenberg (1994) reviewed the basic requirement for good DNA preservation, which is rapid desiccation, a likely occurrence along the coast of Peru. He noted that DNA breakdown (fragmentation) is not linear over time, but initially occurs rapidly due to autolysis and subsequently at a much slower rate due to oxidation. The matrix in which the bone or tissue is interred and the ambient temperature each plays a role in determining degradation. Hagelberg (1993) also pointed out that the superficial tissues are better preserved since lower temperatures and desiccation affect them more rapidly. Allison noted that the minerals in the coastal soils and sands of Peru aid in the preservation of human remains (Allison, 1985). The high altitude coolness of the Andes equally well aided preservation (Schobinger, 1991). Peruvian human remains are well suited to this form of analysis.

Infection

It is more difficult to get this type of information since it requires that the mummy exhibit a disease in such a manner that it is recognized and a search can be made for the pathogen. Clearly, the assumption is that the lesions do not represent a disease process now extinct, but this concern can be removed by recognition of the pathogen.

Allison *et al.* (1971b) described a mummy with Carrion's disease from the Middle Horizon Huari culture. They recognized this disease by the skin nodules and subsequently identified the associated bacteria by thin section and microscopy. This is an example of the high degree of diagnostic accuracy possible with well preserved mummies.

Chagas' disease, endemic to Latin America, has also been observed in Chilean mummy material. Rothhammer *et al.* (1985) autopsied 35 mummies and diagnosed 22 with this disease. The mummies dated between 470 B.C. and 600 A.D. The results of the autopsies suggested that nine had megacolon which was highly suggestive of Chagas' disease. It has been argued that prior to developing sedentary lifestyles, the native peoples would have rarely contracted the disease except on those occasions that they ingested raw meat from animals infected by *Trypanosoma cruzi*, the pathogen responsible. However, once sedentary, the vector *Triatoma infestans* began to live in human habitations and humans became more regularly infected.

Allison *et al.* (1981) reviewed the frequency and appearance of tuberculosis in pre-Columbian Andeans. The visual and radiographic appearances of tuberculosis have, seemingly, not changed over time and the lesions can be readily identified both in mummified remains and in skeletal material. Their sample was small, made up of five Peruvian mummies and six Chilean mummies. They concluded that the incidence and prevalence of tuberculosis and its skeletal manifestations were comparable to other non-treated populations and that the soft tissue pathology of the mummies was the same as in modern populations. They also identified a pattern for skeletal involvement. Intervertebral disc spaces were commonly infected, the infection eroding into the cancellous bone. Metastasis was directly through joints to other bones. A generalized osteoporosis was associated. The lower thoracic and upper lumbar vertebrae were most commonly affected.

Allison *et al.* (1971a) analyzed another indicator of health, that being parasitic infections. They discussed the discovery of the hookworm parasite in a Tiahuanaco mummy dated to approximately 900 A.D. They noted that such parasitic diseases have been found in Egyptian mummies but little has been done to elucidate the prevalence of these infestations in Andean mummies.

Soft Tissue Pathology

Since natural and artificial mummification occurs in the Andes and along associated coastal regions, it is common to encounter lesions and recognize anatomical variants in the mummified remains. Muñizaga, Allison and Aspillaga (1978) described occurrences of diaphragmatic herniation in Chilean Atacamenian Indian mummies from approximately the third century A.D. As well, Muñizaga, Allison and Paredes (1978) described gallbladder disease in Chilean mummies from the same population and considered possible dietary aspects of this disease. In both of these studies the prevalence of the pathology was considered. Of interest were the authors' finding that Peruvian mummies had no gall bladder disease versus a frequency of 3% in the Chilean mummies autopsied. They suggested dietary differences between the populations, particularly the consumption of beans from algarroba trees in Chilean populations.

Another disease observed in a mummy was thyroid disease. Vreeland and Cockburn (1983) reported a female mummy from the Nasca culture with the telltale soft tissue and skeletal changes associated with this disease.

Population Studies

Chile

Allison (1985) did an osteological analysis of mummified remains. He observed external auditory exostoses in 25% of males. There were "squatting facets" at the ankle joint of many females. Females also had close to a 50% rate of discogenic spondylosis of the cervical spine. This disorder is common and its incidence increases with age. This high frequency in females suggests considerable stress to the neck. Osteoporosis was evident in females, representing 31% of the entire mummy population, with a high proportion of these, 67%, being under 40 years of age. There was a low frequency (4%) of evidence of treponemal infection of bone afflicting both sexes. This suggested a division of labour in which males harvested the sea, while females spent significant periods of time in a squatting position with episodes of considerable stress on their cervical spines. Dietary stress for females was evident in the frequency of osteoporosis.

Peru

In the Osmore drainage of Peru, Williams *et al.* (1989), provided some general observations for the approximately 411 burials excavated at the Estuquina site. They indicated that more detailed analysis of the skeletal remains, including palaeopathology, dietary reconstruction and biological relationships of subpopulations would be forthcoming. In this preliminary report they outlined indications of anemia (cribra orbitalia) in children, chronic infection evident as a "tuberculosis-like pathology" (Williams *et al.,* 1989: 341) and cranial deformation (with the bindings creating it). They also indicated that the cemetery sample appeared not to be biased such that detailed demographic analysis was a possibility.

Allison (1984) considered the changes in health as coastal populations became agriculturalists and dependent upon domesticated crops for subsistence. He reviewed the palaeopathology of eight Peruvian populations represented by 418 mummies and eight Chilean populations represented by 361 mummies. He considered osteological, dental and soft tissue indicators of health. Because of the good preservation of remains, infectious diseases were recognizable as well as a number of human parasites. The evidence suggested that sedentary lifestyle, commonly associated with the advent of agriculture led to diminished health. This was characterized by increased levels of chronic and acute diseases in the populations. These diseases were primarily respiratory and gastrointestinal. Parasites were evident at low levels and were not felt to be a major stressor for any of the populations.

Ecuador

Work in Ecuador has provided the most complete analysis of skeletal remains, to date, for this region of South America. Ubelaker (1980a, 1980b, 1981, 1983) has carried out osteological analysis of human remains at several sites, which has allowed the testing of several hypotheses. For instance, Ubelaker (1980a) stated that there are increased death rates in most age classes and increased prevalence of disease over time at the coastal site of Las Vegas (6,000 B.C.). This was related to increased demographic pressure and increasing dependence upon agriculture. In another example (Ubelaker, 1980b) reported that upland peoples had fewer dental caries than lowlanders and less evidence of disease and trauma, but had a lower life expectancy. The most recent remains studied, Guangala phase from Valdivia, (Ubelaker, 1983) although similar biologically to those at other sites and at other periods, had the highest rate of dental caries, except for the Ayalan population (Ubelaker, 1981), perhaps indicating the relative reliance upon agriculture. All populations were of similar stature and had other biological traits at similar frequencies.

One exception to this was the presence of modified metatarsals attributed to kneeling (Ubelaker, 1979). This was first noted at the Ayalan site and was primarily a feature of female skeletons. It has also been described for the Guangala phase population (Ubelaker, 1983) but for none of the others. Development of similar levels of understanding for populations from the North Coast of Peru would allow comparisons over a wider geographic region.

Given the limited number of osteological studies conducted with prehistoric Peruvian skeletal remains, it is no surprise that palaeodemography has not been well developed for prehistoric Peruvian peoples. Many examples could be related demonstrating the potential and failings of such study. (Roth, 1992 reviews the critique of palaeodemography and answers to those concerns.) There is, however, much that could be offered to Peruvian archaeology through palaeodemography.

Ubelaker (1980a, 1980b, 1981) provided demographic information regarding highland and lowland (coastal) populations in Ecuador. He noted that life expectancy at one year of age and in adulthood was lower in upland peoples from Cotocollao (at 1100 B.C. and 540 B.C.) than for peoples living on the Santa

Elena Peninsula (at 6,000 B.C.). The three sets of data he presented were representative of a variety of cultural periods in prehistoric Ecuador and similar data for Peruvian peoples would allow comparison of peoples of differing cultures and altitude zones.

Comparisons within this body of data and with more recent skeletal material allowed Ubelaker (1994) to trace health over time from 8,250 B.P. to the mid 1900's. He contrasted stature, demography and palaeopathology. For the latter, sufficient information was available to consider trauma, periosteal lesions, caries prevalence, alveolar abscesses, dental attrition and enamel hypoplasia. He was able to conclude that the healthiest populations were the earliest, during the low population density, preceramic, preagricultural period. Evidence of infection, dental attrition and disease increased over time until contact. After contact, the trend of decreasing health continued and became steeper. Trauma and infectious disease increased considerably. Demographic trends included an increase in childhood mortality. Increased childhood morbidity was indicated by enamel hypoplasia. Life expectancy at birth and five years of age was its lowest in the early historic and late historic periods. Life expectancy at fifteen years of age and maximum longevity, however, did not diminish.

Palaeodietary Reconstruction

Trace Element Analysis

Although trace element analysis has fallen from favour (see Sandford, 1992; Ezzo, 1994a, 1994b), there has been some dietary analysis of Peruvian populations using this technique. Benfer (1984) analyzed femora of seventeen individuals from the preceramic site of Paloma for eight trace elements and calcium. Strontium and zinc were the only ones for which he presented results. Females had significantly lower zinc levels and were less variable for strontium. Older individuals had the highest strontium levels. Adults could be distinguished from children as could male from female adults by zinc to strontium ratios. High zinc levels in males suggested to Benfer that males had better access to terrestrial meat sources, such as camelids. Ezzo (1994a, 1994b) outlined the difficulties with the use of zinc in dietary studies. His critique is based upon the lack of a model demonstrating the suitability of zinc as a dietary indicator.

Trace element analysis were also used with hair samples. Hair is commonly encountered with mummies as well as in some Peruvian burials where other materials may not be preserved. Benfer *et al.* (1978) have suggested that analysis of hair gives significant information about health and diet over a relatively short and defined time span, since the rate of hair growth is known. They considered hair samples from Paracas dating between 5,000 and 8,800 years ago. The study was preliminary (and the sample size small) and they were unable to detect any age or sex differences in trace elements or changes over time.

Edward and Benfer (1993) have experimentally studied diagenesis of sixteen elements in bones from a cemetery at Paloma, Peru. Sandford (1992) pointed out that diagenesis needs to be better understood for each of the trace elements used in physical anthropological studies. Edward and Benfer (1993) concluded that diagenesis affects all elements to varying degrees. Diagenesis affected adult and subadult bone in similar fashion, however the amount of diagenesis varied with cortical bone thickness and rate of bone turnover (when alive). The latter suggested that it is growth and diet that influenced the bone levels for some elements. They considered Zinc and Strontium least affected by diagenesis.

Stable Isotope Analysis

Stable isotope analysis has proven to be a powerful technique allowing paleodietary reconstruction of human populations and the reconstruction of food webs (reviewed in Katzenberg, 1992; Schwarcz and Shoeninger, 1991). This technique has been used in the Andes and allows greater understanding of human adaptation as well as cultural dietary practices.

Van der Merwe, Lee-Thorp and Raymond (1993) have modeled the isotopic composition of coastal Ecuador as experienced by Formative cultures. Because the ocean current, air masses and terrestrial ecozones are similar, particularly in northern Peru, this background data is also of considerable use to Peruvian prehistorians using stable isotopes. They found a good correlation between marine and terrestrial faunal and plant stable isotopic signatures and their theoretical values. There was little indication of C4 plants in this region prior to maize introduction. Because of this work, stable isotopic signatures found in human bone can be used to give a better approximation of the actual diet.

Stable isotopic analysis of Chilean mummies from Chinchorro indicated that these peoples had a subsistence based upon marine resources (Aufderheide *et al.*, 1993). The mummies were between 4,500 and 7,000 years old and were compared with mummies 2,000 to 3,500 years old from the same region. The results indicated that both groupings relied upon marine resources for 80% to 90% of their protein and that plant matter made up only approximately 8% of their diet (Aufderheide *et al.*, 1993). Seemingly, agriculture was not well developed at either time.

Stable isotope analysis thus provides dietary information as an adjunct to standard archaeological methods for determining subsistence. These include flotation for plant remains, coprolite analysis and faunal analysis as demonstrated in Quilter *et al.* (1991). Since stable isotope analysis "averages" the dietary intake, the archaeological material is important to discern the actual menu enjoyed by the population in question.

The latter is an important consideration since stable isotope analysis is not the final arbiter of dietary reconstruction. DeNiro (1988) looked at the stable isotopic signal from camelids excavated from the sites of Chilca and La Paloma. He determined that some of them were feeding upon or were being fed plant matter from marine or estuary sources. A possible consequence was that humans eating such camelids would pick up the marine isotopic signature without necessarily eating marine resources themselves. This is an important consideration since it is not known how early camelids were present and possibly herded along the coast and how commonly they fed upon marine plants (DeNiro, 1988).

Another approach, developed in Peru, was that of DeNiro and Hastorf (1985). They found that carbonized plant remains could be used to determine the photosynthetic pathway of the living plant which helped in species identification. Further, they were able to distinguish legumes from the other C3 plants by their isotopic signature. This was a good complement to visual recognition. They also observed that recognizable plants tended to yield poorer isotopic results due to diagenesis.

Hastorf and DeNiro (1985) used this technique on pottery sherds from the upper Mantaro valley to analyze food remains, whether cooked or burned. They were able to demonstrate which vessels were used for cooking and that cooking techniques have not changed appreciably since then. Hastorf described cooking vessels as "the most plain self-slipped jarware" (Hastorf, 1985: 20). They analyzed sherds from four cultural phases. These included the Early Intermediate Period/Middle Horizon, Wanka I, II and III periods. These dated between 200 B.C. and 1000 A.D., 1000 and 1200 A.D., 1200 and 1470 A.D. and 1470 and 1532 A.D., respectively.

The results indicated that in the Wanka I period diet involved both maize and native species but that during the Early Intermediate Period/Middle Horizon and Wanka II periods non-leguminous C3 plants predominated. During Wanka III there was insufficient data for comparison, however the greatest differences were between residences of elite and commoner with respect to maize and tuber consumption (Hastorf, 1985; Hastorf and DeNiro, 1985).

Hastorf and Johannessen (1993) carried this further and included results for human bone stable isotope analysis. They also noted changing trends in maize consumption "from a culinary item, simply prepared by boiling, to a more complex symbolic food, transformed through grinding and brewing into beer, with elaborated political meanings." (Hastorf and Johannessen, 1993:115). They were able to develop this thesis based partly upon changes in bone stable isotopes over time. Before Wanka III the dietary proportion of maize was approximately 40% (Hastorf and Johannessen, 1993). During Wanka III the dietary proportion of maize rose to 60%. The ceramic residue isotopic results, previously mentioned, indicated that in Wanka II there was a reduction in maize boiling as food; however, it clearly remained a significant part of the diet. It remained so in another form.

Considering the changing numbers and sizes of vessels and grinding implements over time the evidence suggested that in Wanka II and III the majority of maize was ground. This was and still is the first step in the processing of corn for brewing. Hastorf and Johannessen (1993) argued, as did Burger and van der Merwe (1990), that maize was becoming a symbolic food long before it became institutionalized as such. Its origin as a food staple was co-opted by the political agendas of various groups before and including the Inkas.

Hastorf (1989, 1990) looked more closely at the Wanka III period during which time the inhabitants of the upper Mantaro valley were under Inka control. She reasoned that the archaeological evidence, supported by stable isotope analysis suggested that Inka influence in the Mantaro valley significantly affected all strata of society. The stable isotope analysis demonstrated that maize consumption increased in the Wanka III period paralleling increased production, but that other aspects of their diet remained the same.

Costin and Earle (1989) came to similar conclusions based upon faunal analysis and their interpretation of the cultural changes over time. They argued that commoner and elite had much less distinct diets since their status differentiation was less than before the Inkas took the high status position. These studies clearly demonstrate the utility of incorporating stable isotope analysis into archaeological research. Such analysis clarifies differences between production for subsistence versus taxation and could reveal this for any agricultural crop or any marine or terrestrial meat source.

Burger and van der Merwe (1990), although using a very small sample size, created an argument against maize, as a food source, being important in the development of the Initial Period Chavín cult. They concluded this because maize is not well suited to cultivation at altitude and that other root and seed crops were more important to diet. In their view, maize for fermentation to form *chicha* was more likely, and this product played an important role in religious rites and other aspects of ceremonial activity. Had they a larger sample size made up of individuals of high and low status they may have seen a pattern such as found by Ubelaker *et al.* (1995). Ubelaker *et al.* were able to demonstrate that for highland Ecuador, at a time later than Chavín florescence (100 to 450 A.D. versus 850 to 200 B.C.), higher status individuals had a stable isotope signature indicating greater consumption of maize or its products, such as *chicha*. As such, maize may have had an influence on the earlier Chavín cult but as part of an ideological system and not as a dietary staple.

Conclusion

Human osteological studies have much to offer archaeologists seeking to understand prehistoric human culture in Peru. As previously noted, little of this analysis has been done and there is much that can be revealed regarding the development of "states" in this region. Marine versus terrestrial food procurement and the issues regarding verticality can be addressed by stable isotope analysis. Examples of archaeological considerations of these issues include Aldenderfer (1989), Moseley (1975), Raymond (1981) and Wilson (1981). Such study would also reveal much about population movement and interactions between populations as suggested in Verano and DeNiro (1993). They encouraged the use of morphological, biometric and isotopic techniques to elucidate a population or an individual's origin. It may be possible to trace the development of status hierarchies within groups by identifying differential dietary practices and lifestyle as revealed by DNA sequences, stable isotope analysis and osteological analysis.

An area suited to addressing several of these issues is the North Coast of Peru. For example, the Cupisnique cultural complex of the Moche, Chicama and Jequetepeque valleys was a culture of the Initial Period, a time when many Andean adaptations were being developed and formalized (Burger, 1992). Burger noted the presence of maize, at low levels and evidence of trade of ceramics and iconography both to and from the highlands. The Cupisnique cultural complex is a window into the development and implementation of these adaptations as well as the associated social changes.

Opportunity exists in the Jequetepeque valley to consider many of these influences directly by stable isotope analysis and osteological analysis of skeletal remains of the people dating from the Initial Period. Burger (1992) pointed out that this valley is a natural corridor into the highlands and has a number of sites ranging from coastal fishing villages to larger agricultural sites in the lower valley. Village sites and cemeteries are also known in the *yunga* zone between 350 and 450 meters elevation. Many of these sites have been argued to be highland intrusions into the valley and not coastal outposts. Which of these is the case may be revealed by analysis of the diet and genetics of the populations that lived at these sites.

The coastal ecosystem also underwent considerable environmental disruption during the Initial Period (reviewed in Burger, 1992). These upheavals included tectonic activity and a major El Niño event. The cultural and biological effects of this upheaval may be discernible in the coastal populations. This would include the success or failure of their adaptation to these changing environmental conditions.

This chapter has reviewed previous studies considering indicators of health and nutrition in prehistoric Andean peoples. Studies of paleopathology evident in bone and mummified soft tissues have been reviewed. Population level studies have been reviewed including their utility in the comparison of overall health status among different cultures. As well, recent studies using chemical analysis of bone for dietary reconstruction and consideration of food distribution in Andean cultures have been reviewed. The background this provides sets the stage for the research possibilities outlined above as well as the present study.

Chapter 3 - A Summary of North Coast Prehistory During the Initial Period and Early Horizon

Archaeology

The North Coast chronological sequence was summarized in Table 2.1. The cultural distinctions are based upon ceramic seriation forming a relative chronology in alignment with stratigraphic relationships. Dating for these Periods and Horizons are not consistent from valley to valley along the coast since the development and transmission of cultural features was not simultaneous along the coast of Peru.

Human populations have inhabited the Peruvian North Coast since 12,795 B.P. in the Moche Valley (Chauchat, 1988). In the Pampa de los Fosiles, which is the desert between the Jequetepeque River and the Chicama River there is evidence of human habitation back to 10,380 B.P. (Chauchat, 1988).

These early people were hunter-gatherers. Chauchat (1988) reviewed their subsistence which consisted of a variety of fish species, terrestrial snails (*Scutalus sp.*), lizards (Dicrodon and Callopistes), as well as a variety of other small game. No middle sized species (deer, bear, puma) or large species (horse, giant armadillo, Eremotherium, Paleolama or Haplomastodon) have been found associated with the campsites of these people. They were apparently specializing in the smaller Pleistocene/Holocene fauna. After the time of these "Paijanese" there was a gap of approximately two millennia before there is further evidence of habitation in this region (Elera, 1993; Lanning, 1967). The Paijanese cultural period is Preceramic IV in the Peruvian Chronology of Lanning (1967).

The next cultural groups in this region are those of the Late Preceramic and Initial Period. It was during this time frame that "the beginnings of more complex social organization become apparent and societies exhibit the progressive urbanization which was to engender, as the physical expression of Andean civilization, public architecture on a grand scale" (Fung Pineda, 1988: 67). Sites from early in this period are associated with ceremonial mounds, and later with large U-shaped ceremonial structures with stone facades. The construction of these represented considerable effort on the part of the local populations. Fung-Pineda (1988) suggested that the first stratified societies belonged to peoples at these coastal sites.

Developments during this time created the potential for the cultural development that occurred in the latter part of the Initial Period and into the Early Horizon (Elera, 1993). In the Jequetepeque Valley the Montegrande culture was the first Initial Period culture. It preceded the Cupisnique cultural complex and may have been its cultural predecessor (Elera, Pinilla and Vasquez, 1992).

As pointed out above, distinctions between cultures are commonly based upon stylistic differences and patterns of iconography in ceramics. Cupisnique ceramics demonstrate a very close affinity with Chavín forms (Elera, 1993). The ensuing Salinar culture, which is post Chavín, can be distinguished from either culture but shows iconographic affinity with the Late Cupisnique phase (Elera, 1997). The Cupisnique cultural complex has been termed "Chavinoid" (Proulx, 1985) or Chavín (Donnan and Mackey, 1978) or Coastal Chavín (Proulx, 1985). In fact, Elera (1993) pointed out that Classic Cupisnique and Classic Chavín have been confused by some scholars.

The Cupisnique cultural complex passed through three phases. Early and Middle or Classic sites have been found on the coastal zone at locations such as Puémape as well as to a lesser extent in the mid valley regions (Elera, 1997). There is also a ceremonial centre and cemetery at Puémape dating from the Late Cupisnique phase. These phases date between 1200 and 900 B.C. (Early Cupisnique), 900 and 500 B.C. (Classic Cupisnique) and 500 and 400 B.C. (Late Cupisnique). The subsequent Salinar culture dates between 400 and 100 B.C. (Elera, Pinilla and Vasquez, 1992).

During the mid to later part of the Initial Period, sites are typically found further inland (Carlos Elera, personal communication). Keatinge (1980), in a survey of sites along the Jequetepeque River valley found sites as much as 50 kilometers inland that he attributed to the Late Cupisnique phase.

The archaeological evidence suggests that the Late Cupisnique phase was abruptly terminated by the population moving inland from the coast (Elera, 1997). This seems to have been a common phenomenon along the entire Central and North Coast regions (reviewed in Burger, 1992). This process began during the terminal part of the Initial Period and continued throughout the

Early Horizon. Depopulation varied in extent along the coast, but appears to have been complete at the site of Puémape. The migrating people moved inland as far as the mid valley region with their influence reaching as far as Kuntur Wasi (Carlos Elera, personal communication). After the inland migration of Late Cupisnique phase populations, there was a time, of unknown length, before which the coast was again inhabited (Shimada, 1994).

The peoples that re-inhabited the coastal regions were associated with Salinar pottery. They may or may not have been descendants of the people who vacated the region. They may have moved into the lower Jequetepeque River valley from further north (Carlos Elera, personal communication) or from the northern Peruvian highlands (Shimada, 1994).

How quickly the Late Cupisnique phase population left the coastal region is not known nor are the reasons for it fully understood. There is evidence for a major El Niño event or tsunami (Bird, 1987) at the time of this migration. Shimada (1994) suggested that the movement of sand dunes such as those covering the Cupisnique site at Puémape could be the result of tectonic forces and coastal uplift. Moseley *et al.* (1981) pointed to shoreline uplift totaling over 8 meters in the Moche valley between 1500 and 1000 B.C. Prior to 1500 B.C. the land levels were much as they are today. Moseley *et al.* (1981) also point to a major El Niño event at 500 B.C. that led to considerable erosion of coastal sediments.

However, Burger (1992) pointed out that the region may have been evacuated prior to the time of these events. Bird's review of the dates for this inland migration placed its beginning between 890 and 715 B.C. and being completed with a tsunami at 500 B.C. (Bird, cited in Burger, 1988). This would correspond to the transition from the Classic Cupisnique phase to the Late Cupisnique phase. He then placed the repopulating of the coast in Salinar times at approximately 200 B.C. based upon the spread of pottery related to this culture. The Salinar culture continued until the Gallinazo culture, indicated by new ceramic styles, at about A.D./B.C.

The El Niño phenomenon occurs irregularly during the summer season. Major events occur regularly every 20 to 25 years with very large events occurring more infrequently (Burger, 1992). As such, the coastal peoples, particularly on the north coast, would be familiar with these occurrences. The north coast would be the first coastal region to feel the effects of an El Niño and even a moderate El Niño would affect this region more than southerly coastal regions.

An El Niño sufficient to move populations inland would have to be severe and prolonged or temporally linked to some other major event. Inland migration made sense, not just to avoid the decimated coastal regions, but because that was the direction of trade routes to inland populations (Burger, 1988). The inland sites would also have agricultural potential long after the coastal sites since mid to upper valley irrigation systems would likely be the first repaired after a major catastrophe (Shimada, 1994). Shimada (1994) also pointed out that the Jequetepeque valley is, on the North Coast, the farthest valley to the north offering good access to the highlands.

The Salinar culture followed the Late Cupisnique phase between 400 and 200 B.C. (Burger, 1992) depending upon the region of the North Coast. Burger also noted that it was at this time that a militaristic pattern had evolved with forts and decreased long distance trade. Local, within valley, alliances were believed to be maintained, however. Salinar culture was constituted by a stratified society (Burger, 1992). Elera (1997) suggested that, based upon study of ceramic iconography, Salinar people at Puémape were actively incorporating Cupisnique motifs in their pottery. The Salinar occupation at Puémape covered approximately 20 hectares (Elera, 1997). This large site was made up of ceremonial areas, residences and cemeteries that overlie the preceding Late Cupisnique site. Many of the Salinar burials at Puémape were intrusive into the underlying Cupisnique ruins.

Architecture

Architecture associated with the Cupisnique cultural complex comes in two forms, the remains of dwellings and monumental architecture. The latter were constructed of adobe making them very resistant to decay, and have received much more attention. The monumental architecture took the form of U-shaped structures similar in pattern to those from the preceding Initial Period, with alterations in keeping with the ideology of the Cupisnique cultural complex. Burger (1992: 92) described the overall pattern of these structures as:

> "Generally speaking, the public buildings consist of relatively low tiered platforms, massive central inset stairways, and rectangular forecourts. The creation of elaborate colonnades is perhaps the most distinctive element of early north coast public architecture. As in other parts of the coast, painted adobe sculptures adorned building exteriors, and low lateral mounds often produced a U-shaped layout....It would appear that although ritual entombment and rebuilding was practiced on the north coast,... it was also common periodically to shift location of ceremonial building. This produced many relatively small mounds, rather than fewer awe-inspiring constructions."

These ceremonial buildings were made of adobe and often plastered with clay and inscribed and/or painted with images from their mythology. Residential buildings were more modest and consisted of adobe and totora reed construction.

The largest of these sites is in the lower Moche valley at Huaca de los Reyes (reviewed in Burger, 1992). It is part of the 200 hectare inland site at Caballo Muerto which was inhabited before and throughout the time of the Cupisnique cultural complex. In the Jequetepeque valley the largest site was in the lower valley at Limoncarro. It is situated 20 kilometers inland from Puémape where the valley floor rises from the desert coast land.

Architecture from the Salinar phase has been identified at several sites. At Cerro Arena, a site in the Moche Valley, structures were made with granite from local rock outcrops (Brennan, 1980). Brennan described this site as an urban centre composed of residential housing of varying size and structure demonstrating a level of nucleation not previously recognized for this time period. He stated "this site area covers an expanse of *ca.* 2.0 sq. km., and contains a *minimum* of 2,000 separate structures of varying sizes" (Brennan, 1980: 3). He defined three "specialized activity areas" (Brennan, 1980: 16), three structure types and five room types at the site. He argued that this is suggestive of a complex ranked society, but without the segregation of the individual classes evident in the succeeding Moche culture. Brennan (1982) identified a similar pattern of Salinar centers of varying size in several other valleys, from the Jequetepeque in the north to the Viru in the south. The larger urban centers were primarily at key resource sites (canals and farmland) and at strategic points along intervalley and intravalley trade routes.

Quality of construction at Cerro Arena varied considerably (Brennan, 1980, 1982). Buildings had walls varying in quality between those crudely built of plain rock to others of finely fitted stones with a clay plaster surface. Roofing of the Salinar buildings at Cerro Arena appeared to have been "dried grass laid over canes or poles" (Brennan, 1980: 5) in the more modest structures. Brennan stated "In the more elaborate buildings larger, rectangular rooms normally had roofs constructed of a 5-15 cm. thickness of dense clay over canes, and in turn covered by a thin layer of flat granite flakes or spalls."(Brennan, 1980: 6). Floors in these structures varied between bare ground and clay plaster over sand.

Shimada (1997), analyzed adobe brick making techniques and patterns of adobe placement and suggested that ceremonial structures were built by unified groups during the Cupisnique cultural complex and Salinar culture. This contrasted with later Gallinazo and Moche buildings that were built by a number of local, perhaps kin-based groups. Each of these groups was responsible for erecting a portion of a ceremonial structure. Each group often marked their adobe bricks for identification to be able to demonstrate fulfillment of their obligations.

Ideology

Burger (1992) stated that ideology associated with the Cupisnique cultural complex was based upon the shamanistic ideology of their forebears. It focused, iconographically, on the spider and the feline. Paraphernalia for the use of hallucinogens has been found (Elera, 1997) and Cupisnique iconography includes themes that have been interpreted as dealing with transformation from human to feline form. These features, combined with geometric designs on their ceramics, are believed to be part of a coastal traditional that was later incorporated into Chavín ideology (Elera, 1997). Part of this ideology included spondylus shells, anthracite and semi-precious stones. During the Classic Cupisnique and into the Late Cupisnique phase the use of metals became common. These metals included copper, silver and gold (Elera, 1997). The mollusc shells, particularly spondylus shells, minerals and metals were imported to this region.

The Late Cupisnique phase which was coeval with Classic Chavín has been classified as a time of "vigourous, intense ceremonialism" (Elera, 1997: 191). This follows the cultural developments of the Classic Cupisnique phase during which valleys became united through resource controlling elites (Elera, 1997). Demonstration of power and status would be a function of the ceremonial activity.

Mortuary Practice

Evidence of the Cupisnique cultural complex can be found at coastal sites from the Viru Valley in the south to the Lambayeque in the north. One cultural practice linking this large region was the treatment of interments. Elera (1993) noted that Early and Classic Cupisnique phase populations were buried in a flexed position, but that Late Cupisnique phase and Salinar populations were buried in an extended position. The typical burial pattern was that of irregularly shaped pits dug into the subsoil into which a flexed corpse was placed on its side or back (Burger, 1992). At Puémape the bodies were wrapped in matting of totora reed, with an inner wrapping of cotton. A variety of pottery types and styles were buried with the bodies, the classic form being the stirrup-spout bottle. A variety of objects of personal adornment can also be found with interments, as well as small objects of religious significance. Often one or more stones of varying size were placed above the body, but within the grave (Carlos Elera, personal communication).

Subsistence

Subsistence practices during the Cupisnique cultural complex and Salinar culture did not change appreciably (Burger, 1992). The standard pattern of economic activity involved coastal villages like Puémape harvesting marine resources and trading these items to villages producing agricultural products in the lower river valleys. Trade with highland and mid valley centers was minimal (Burger, 1992; Carlos Elera, personal communication). This allowed the entire coastal population to have access to the full range of available resources. Centers such as Limoncarro and Huacos de los Reyes in Caballo Muerto were situated at sites that allowed control over river resources (water) and the canal systems required for irrigation.

The economy of the Cupisnique cultural complex was based upon practices dating from earlier in the Initial Period. Fish hooks and nets, stone flake technology, fire starting technology and agricultural technology did not change markedly (Burger, 1992). Digging sticks and stone clod breakers were the agricultural tool kit and were combined with flood plain agriculture in the lower Jequetepeque Valley. The only significant change was the use of irrigation to intensify agriculture. The populations were sedentary throughout this time period.

The use of totora reed boats allowed these coastal peoples to fish up to 1 kilometer out to sea (reviewed in Wilson, 1981). This was sufficiently far to reach many species, including pelagic species on a seasonal basis (reviewed in Quilter and Stocker, 1983). This is assuming that these boats were used during the Initial Period, since their evidence, archaeologically, only goes back as far as B.C./A.D. (Wilson, 1981).

Anchovies, sardines and other fish were caught with seine nets of varying mesh size. Larger fish were also taken by hooks on cotton lines (Burger, 1992). Quilter and Stocker (1983) also reported anchovy beachings sufficient in size to feed significant numbers of people. Shellfish was gathered along the coast, particularly mussels (*Mytilus chorus or M. magellanicus*), clams (*Mesodesma donacium* Lamarck), crabs, sea urchins (Echinoidea) and both terrestrial and marine snails. More complete listing of species utilized along the Peruvian coast can be found in Pozorski (1979) and Quilter *et al.* (1991).

Pozorski's work (1979) gives the best estimate of resources at Puémape since the Moche valley is approximately 100 kilometers south of the Jequetepeque valley. At some sites it appears that the fish and shellfish were dried and stored for lean periods (Burger, 1992). Sea mammals were hunted, particularly sea lions *(Arctocephalus australis* and *Octavia flacescens*). These coastal populations ate a wide range of oceanic birds including cormorants (*Phalacorax sp.*), pelicans (*Pelcanus sp.*), boobies (*Sula sp.*) and penguins. Protein sources along the coast remained fish, shellfish and sea mammals throughout the Early Horizon. Inland communities also utilized camelids such as Llama (*Llama glama*).

A primary fish species harvested by these people was anchovetta (*Engraulis ringins*). These smaller fish were used extensively during the Initial Period as well as larger species such as corvina (*Sciaena deliceosa*) and bonito (*Sarda chilensis*). These species were also used extensively in the Late Preceramic Period on the North Coast (reviewed in Wilson, 1981).

Prior to the Early Horizon, during the Initial Period, domesticated food and plant fiber sources were already fully exploited (Keatinge, 1988; Burger, 1992; Quilter, 1991). On the North Coast, the primary domesticated plant fiber source was cotton (*Gossypium barbadense*). Wild plants harvested for non-food use included marsh grasses (*Scirpus sp.* or *Cyperus sp.*), totora reed (*Typha angustifolia*) and the algorroba tree (*Prosopis chilensis*) (Parsons, 1970). Plant crops included ullucu (*Ullucus tuberosus*) bottle gourd (*Lagenaria siceraria*), squash (*Curcurbita sp.*), peppers (*Capsicum sp.*), lima and kidney beans (*Phaseolus lunatus* and *vulgaris*), jack bean (*Canavalia sp.*), maize (*Zea mais*), peanuts (*Arachis hypogaea*) and pacai (*Inga feuillei*). Fruit species included avocado (*Persea americana*), lucuma (*Lucuma abovata*) and guayava (*Psidium guajava*). Other domesticates grown locally or traded from inland sites included manioc (*Manihot sp.*) (Larco Hoyle, 1936), potatoes (*Solanum sp.*) and sweet potatoes (*Ipomoea batatas*) (Bird, 1988).

Over time the relative proportion of marine to terrestrial foods appears to have changed (Carlos Elera, personal communication). Initially, diet was biased toward the marine component but this shifted as the Early Horizon progressed.

A contentious part of this change was a possibly greater reliance upon maize at the beginning of the Initial Period. This was noted in one North Coast valley, the Casma (Pozorski and Pozorski, 1988). According to Burger, this trend was evident along the entire North Coast (Burger, 1992). Pozorski and Pozorski suggested that an invading population brought this cultigen. Burger and van der Merwe (1990) pointed out, however, that based upon stable isotope analysis, maize did not make up more than 25% of diet at Chavín de Huantar, the center of the Chavín cult.

Pozorski (1979) in her consideration of the Moche valley came to a similar conclusion. A coastal site, Gramalote, dating from the Cupisnique cultural complex had less than 0.1% *Zea mais* remains evident at the site. Evidence of cultivated plants indicated that peanut (*Arachis hypogaea*), peppers (*Capsicum sp.*), squash (*Curcurbita sp.*), avocado (*Persea americana*), cansaboca (*Bunchosia armeniaca*) and lucuma (*Lucuma obovata*) were the primary cultigens. Squash and lucuma were, by far, the most prevalent. Identifiable wild plants utilized for weaving, twining, fuel or a building material included cane (*Gynerium sagittatum*), totora (*Scirpus tatora*), achupalla (*Tillandsia sp.*) and algorroba (*Prosopis chilensis*).

Pozorski's analysis of mammalian remains indicated that sea lions (*Otario byronia*) were the most common identifiable species. Fish species were primarily shark (*Mustelus sp.*), others representing less than 1%. Purple crab (*Platyanthus orbignii*) was the only crustacean identified as a harvested food source. Molluscs made up the bulk of species used as food at Gramalote. Purple muscle (*Choromytilus chorus*), larger clam species (*Protothaca thaca*, *Eurhomalea rufa*, *Gariet solida* and *Semele corrugata*) and the gastropod *Tegula atra* made up species representing over 1% of shell refuse.

Over the course of the Cupisnique cultural complex there developed significantly more long distance trade, either up the Jequetepeque Valley, as far as Kuntur Wasi, or north and south along the coast (Burger, 1992; Carlos Elera, personal communication). Trade up and down valleys continued to be the most important. The most common pattern was trade between coastal villages on the littoral that supplied fish and shellfish to inland agricultural villages in exchange for their products.

There was also considerable variation in the availability of food resources. The prime mover for this variation was not so much the seasonality of resources, but the El Niño that dramatically affects the entire coastal ecosystem (Parsons, 1970). Parsons indicated that the last major El Niño event, in 1925, turned the desert coast into a garden, while decimating the oceanic ecosystem. She suggested that it was to this desert turned garden that the preceramic peoples and possibly later peoples turned to for subsistence when the El Niño disrupted the marine environment. Shimada (1994) also took this view and suggested that small coastal lakes may have developed in the Jequetepeque valley consequent to the El Niño rains. These would have allowed cultivation of land otherwise too arid for agriculture. He further suggested that lands of marginal agricultural potential in the upper valley may have become important when they received El Niño rains.

Chapter 4 - **Results**

Study Population

The age and sex data for the interments studied are shown in Tables 4.1, 4.2 and 4.3. The Early Cupisnique sample included two infants, seven children, nine adult females, five adult males and one adult of unknown age and sex. The Classic Cupisnique sample population was made up of ten infants, eleven children, ten adult females, two adult males and nine adults of unknown age and sex. The Salinar sample included five infants, eight children, eight adult females, sixteen adult males and one adult of unknown age or sex.

Average age at death for the study population as a whole was 34.0 years. For the Early Cupisnique population the average age at death was 38 years, 36 years for the Classic Cupisnique population and 31 years for the Salinar population. This was calculated by summing the age at death for all individuals in a population and averaging this figure. Ubelaker (1980a; 1980b; 1983) used this calculation. This allowed a means of comparing the populations from Puémape with his populations from Ecuador.

Table 4.1 - Early Cupisnique Population Sample

Interment	Sex	Age	Remarks
XXXI	Unknown	Child	
XXXII	Female	Old Age	
XXXIII	Male	Young Adult	
XXXIV	(Female)	Young Adult	
XXXV	Female	Young Adult	
XXXVI		Old Age	
XXXVII	Unknown	Child	MNI = 2
XLIV	Male	Middle Aged	
LXXXII	Unknown	Child	
LXXXIII	Female	Young Adult	
LXXXV	Unknown	Unknown	not interred with usual cotton wrappings
LXXXVI	Unknown	Child	
LXXXVII	Unknown	Adult	
LXXXVIII	Female	Young Adult	
LXXXIX	Male	Middle Aged	
XCII	Male	Old Age	
XCIII	Unknown	Child	
XCIV	Female	Adult	
XCVII	Unknown	Young Adult	
XCVIII	Unknown	Child	
CX	Female	Young Adult	
CXI	Unknown	Infant	MNI = 3
CXIII	Male	Young Adult	

CXV	Female	Unknown	not interred with usual cotton wrappings

24 interments total; () = tentative assignment of sex; age intervals defined in text.

Table 4.2 - Classic Cupisnique Population Sample

Interment	Sex	Age	Remarks
I	Female	Unknown	
XX	Unknown	Infant, (Adult)	MNI=2
XXI	Female	Young Adult	
XXII	Unknown	Child	
XXIII	Unknown	Infant	
XXIV	Unknown	Unknown	
XXV	Female	Old Adult	
XXVI	Unknown	Unknown	
XXVII	Unknown	Infant	disturbed burial
XXVIII	Unknown	Child, Adult	MNI=2
XXIX	Unknown	6 months	
XXX	Unknown	6 months	
LVIII	Female	Young Adult	
LIX	Unknown	Infant	
LX	(Female)	Unknown	
LXI	Unknown	Adolescent	
LXII	Unknown	Unknown	MNI=2
LXXV	Female	Middle Aged	
LXXVIII	Unknown	Unknown	disturbed burial

LXXIX	Unknown	Infant	
LXXX	Unknown	Child, Adult	MNI=2, disturbed burial
XC	Unknown	Child	
XCI	Unknown	Child	
XCV	Female	Young Adult	
XCVI	Unknown	Infant	
XCIX	Unknown	Child	
C	Female	Young Adult	
CI	Unknown	9 months, Adult	MNI=2
CII	Unknown	Infant	
CIII	Unknown	Adult	
CIV	Unknown	Unknown	
CV	Unknown	Child	
CVI	Male	Unknown	
CVII	(Female)	Unknown	disturbed burial
CVIII	Unknown	Unknown	disturbed burial
CIX	Female	Middle Aged	
CXII	Unknown	Child	
CXVI	Unknown	Child	
CXVII	Male, Unknown	Old Age, Child, 2 Adult	MNI=4
CXVIII	Unknown	3 Adult	MNI=3, disturbed burial
CXX	Unknown	Child, 2 Adult	MNI=4, disturbed burial

41 interments total

Table 4.3 - Salinar Population Sample

Interment	Sex	Age	Remarks
IIIA, IIIB	Female, Female	Unknowns	
IV	[Unknown]	[Infant]	MNI=9 for partially commingled interments IV to VII
V			
VI			
VII	(Male)	Young Adult	
VIII	Female	Young Adult	
IX	Male	Adult	
X	Male	Middle Aged	
XI	Female	Young Adult	
XII	Unknown	Child	
XIII	Female	Old Adult	
XIV	Unknown	Child	
XV	Unknown	Unknown	
XVI	Unknown	Child	
XVII			canid
XVIII			canid
XIX			skeleton not available for analysis
XXXVIII	Male	Young Adult	
XXXIX	Male	Young Adult	
XL	Male	Young Adult	
XLI	(Female)	Middle-Old	

		Adult	
XLII	Unknown	Child	
XLIII	Male	Young Adult	
XLV	(Female)	Middle Aged	
XLVI	Unknown	6 months	
XLVII	Male	Young Adult	
XLVIII			canid
XLIX			canid
L	Female	Old Adult	
LI			skeleton not available for analysis
LII			canid
LIII	Male	Middle Aged	
LIV			canid
LV	Unknown	Child	
LVI	Unknown	Infant	
LVII	Unknown	6 months	
LXIII	Unknown	6 months	
LXIV			canid
LXV			skeleton not available for analysis
LXVI	Male	Young Adult	
LXVII	Male	Young Adult	
LXVIII	Male	Young-Middle Aged	
LXIX	Male	Middle Aged	
LXX	Unknown	Child	
LXXI	(Male)	Young Adult	

LXXII	Unknown	Child	
LXXIII	Unknown	Child	
LXXIV	Male	Middle Aged	
LXXVI	Male	Middle Aged	
LXXVII	Unknown	Child	
LXXXI	Unknown	Unknown	
CXIV			skeleton not available for analysis
CXIX			canid

53 interments total; () = tentative assignment of sex

Several interments were not studied since they were not available. Other interments were canids. Dog burials were common during the Salinar phase and made up 8 of 53 excavated Salinar interments at Puémape. Since the entire cemetery was not excavated it is not clear whether dog burials were this common overall. Carlos Elera, who co-directed the archaeological excavation at Puémape, indicated that it is believed that the dogs were associated with the ideology of the Salinar people. Canid interments were one aspect of Salinar culture that distinguished it from the preceding Cupisnique cultural complex. They were often buried with the cotton wrappings common to human burials (Carlos Elera, personal communication).

The interments from Puémape do not represent a random sample of those dying in these cultures. Carlos Elera (personal communication) indicated that only a small percentage of the entire cemetery was excavated. This was because the primary purpose of the excavation was directed toward the architectural features of the site. The interments disinterred were found buried in the ruins of the cultural features of preceding cultures. As well, Carlos Elera (personal communication) suggested that there were designated areas in the cemeteries for different age groups. This view is reinforced by the age at death distribution (Figure 4.1). Very few deaths are recorded from the one to five year old age group. In most cultures this is a time when the stresses associated with weaning lead to increased mortality (Katzenberg *et al.*, 1996).

Other factors influencing recovery of interments are damage to the burials, discussed below, and loss of skeletal remains. The latter refers to the loss of osteoporotic remains of individuals of all ages as well as infant remains due to decomposition. Reasons for this are reviewed in Saunders (1992) and include factors such as soil pH, contact of the skeletal elements with the soil and level of water table. She concluded, however, that differential burial practices for infants was a major bias in skeletal recovery.

Skeletal preservation was much poorer in the Classic Cupisnique cultural phase than in the Early Cupisnique phase or Salinar culture, generally due to damage done when the interments were disturbed prior to excavation (Tables 4.1; 4.2; 4.3). In the Early Cupisnique sample, the only adult skeleton that could not be identified for age or sex (interment LXXXV) was one of only two not interred with the usual wrappings. The other (CXV) could be identified for sex but not age. Only four of the Classic Cupisnique sample that could not be identified for age or sex (interments XXVI, CIII, CIV, CVI,) were undisturbed burials. The remainder had been disturbed. These included XXVIII, LXXVIII, LXXX, CVII, CVIII, CXVIII and CXX. Of the Salinar interments the only one unidentifiable for age or sex was an undisturbed adult burial (LXXXI).

Interment XXXVII from the Early Cupisnique cultural phase and interments XX and CI from the Classic Cupisnique cultural phase were infant or child burials, however some adult elements were included with these interments. Interment XX was further unique in that the lower limbs and pelvis showed indication of having been burned. Carlos Elera (personal communication) indicated that the former was likely due to disturbance of the graves at some point prior to excavation. He suggested that interment XX may have been an infant sacrifice.

Estimation of Age of Subadults

Age estimation was accomplished using standard techniques as described in Buikstra and Ubelaker (1994). Dental age was assigned according to the standards in Ubelaker (1989) based upon a Native American population.

The fetal, infant and child skeletal material examined in this study was measured using a sliding caliper according to the methodology described in Buikstra and Ubelaker (1994) which is based upon Fazekas and Kosa (1978).

These measurements were then used to determine age according to Gindhart (1973), Scheuer *et al.* (1980) and Ubelaker (1989).

Age at death categories were as follows: Infants are those under 1 year of age, children are age 1 to 12 and adolescents are from 13 to 20 years of age. Adolescents are aged by a combination of dental development and epiphyseal fusion. Epiphyseal fusion was estimated according to Ubelaker (1989).

Estimation of Age and Sex of Adults

Adult age classes are young adults (aged 20.1 to 40 years of age), middle aged adult (40.1 to 50 years of age) and old adults (over 50 years of age). Age was determined according to known age related changes in sacro-iliac joints, the pubic symphysis and the sternal ends of ribs. Todd (McKern and Stewart, 1957) and Suchey-Brooks (Brooks and Suchey, 1990) pubic symphysis methods were used. Buikstra and Ubelaker (1994) outlined these methods as well as the auricular aging technique. Aging using the sternal end of ribs was done according to the description and criteria in Ubelaker (1989).

Sex determination was accomplished according to the criteria in Buikstra and Ubelaker (1994). Qualitative os coxae and skull features were used in sex determination. Os coxae features used were ventral arc, subpubic concavity, ischiopubic ramus ridge, greater sciatic notch and preauricular sulcus. Cranial features used were nuchal crest, mastoid process, supraorbital margin, prominence of glabella and mental eminence. As many of these features as possible were used in sexing the remains. Where there was a discrepancy in assigning sex between pelvic and cranial features, the pelvic features were given priority.

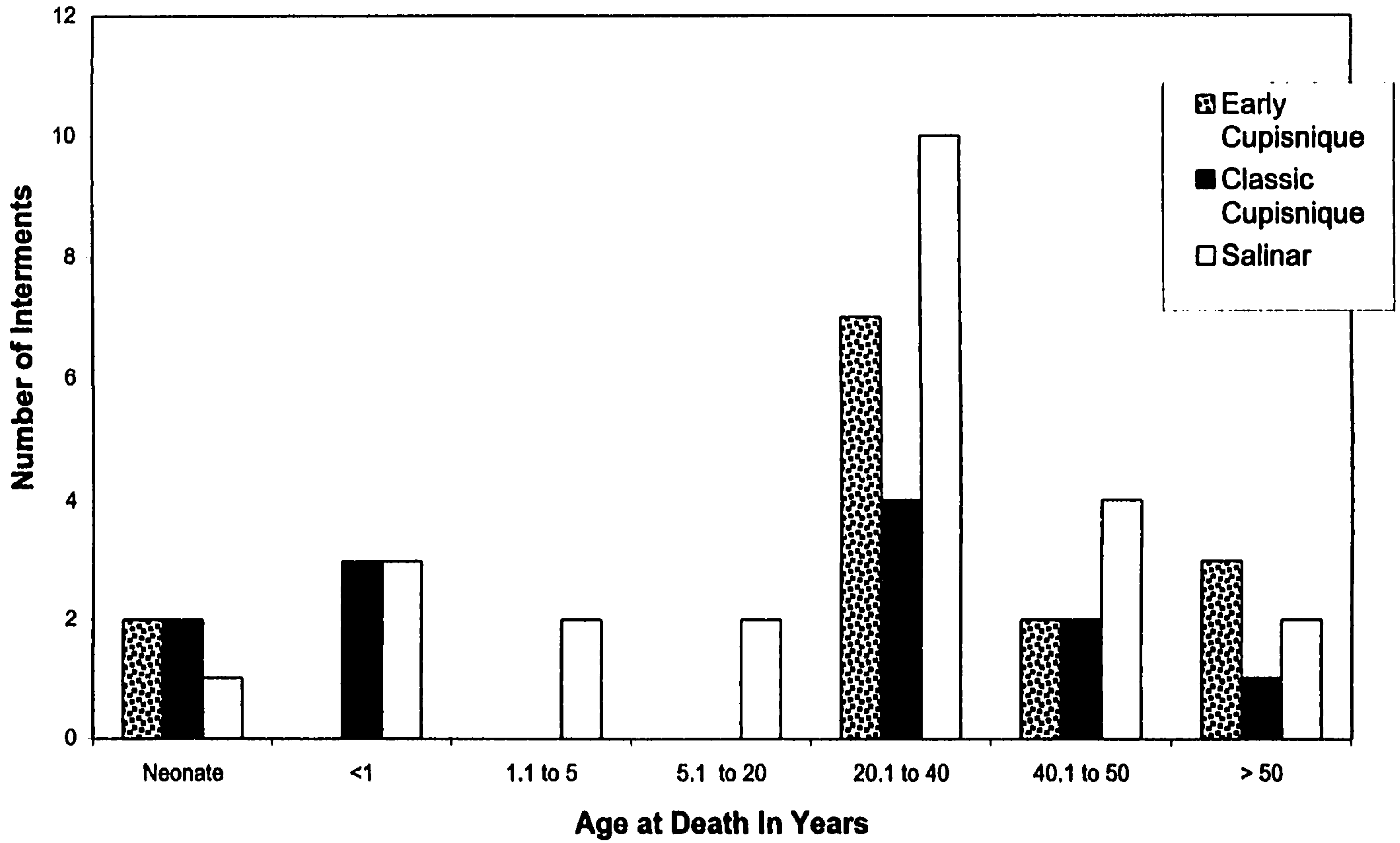
Dental Analysis

Dental attrition and pathology were classified according to the material in Buikstra and Ubelaker (1994). Dental surface wear was determined according to their modifications of the method of Smith (1984) for premolars, canines and incisors. The method of Scott (1979) was used for molar wear. Dental hypoplasia was evaluated according to the criteria in Buikstra and Ubelaker (1994). Caries data is presented as the number of individuals with associated teeth showing caries as a percentage of the total number of individuals. Caries Rates were not calculated for each tooth type nor was a Diseased Missing Index calculated (as done, for example, in Saunders *et al.*, 1997) since I (unfortunately) did not distinguish between teeth lost antemortem or postmortem and I did not count the total number of teeth associated with each interment.

Radiographic Analysis of Skeletal Material

Radiography of the skeletal materials was done, in Peru, by Dr. Gustavo Elera Nuñez. He is a Peruvian medical doctor with a specialty in radiology (the specialty completed in Germany). These X-rays were evaluated by Dr. Elera Nuñez and myself. Dr. Elera Nuñez used standard medical analysis, including a light box, for determination of Harris lines and other pathology, while I used a fluorescent overhead light source and an incandescent light for detailed analysis.

Figure 4.1 - Age at Death Distribution for Interments at Puémape



Early Cupisnique Osteology

Age Estimation of Infants and Children

Results of dental and long bone age estimates are in Table 4.4. None of the Early Cupisnique infants (interment CXI) were complete enough to allow dental aging. According to the ages derived from long bone lengths (Scheuer, Musgrave and Evans, 1980) they were either stillborn (39 weeks gestation) or miscarriages (35 weeks gestation). Comparison with Ubelaker (1989) was in agreement, although these ages were at the lower limit or below the limits of his chart.

Harris Lines

Only one individual from the Early Cupisnique phase had Harris lines. This was interment XXXIII, a young adult male. He had an unspecified number of these lines in his humeri. (This was an observation of Dr. Elera Nuñez who typically did not quantify these lines. I did not observe any lines in this individual.)

Table 4.4 - Dental Ages and Ages Derived from Long Bone Lengths for Infant and Child Interments at Puémape

Interment	Cultural Affinity	Dental Age	Age Derived from Long Bone Length (Gindhart 1973 or Scheuer *et al.*, 1980)	Age Derived from Long Bone Length (Ubelaker, 1989)
XVI	Salinar	NA	18 to 24 months	6 to 12 months
XXVII	Classic Cupisnique	Neonate	37 weeks gestation	below table limit
XXIX	Classic Cupisnique	6 months	3 months	0 to 6 months
XXX	Classic Cupisnique	6 months	3 months	0 to 6 months
XLVI	Salinar	6 months	1 to 3 months	0 to 6 months
LVI	Salinar	NA	31 weeks gestation	below table limit
LVII	Salinar	6 months	6 weeks	0 to 6 months
LXIII	Salinar	6 months	1 to 3 months	0 to 6 months
LXXXI	Salinar	18 months	12 months	6 to 12 months
XCVI	Classic Cupisnique	NA	39 weeks gestation	0 to 6 months
CI	Classic Cupisnique	9 months	3 months	0 to 6 months
CII	Classic Cupisnique	Neonate	38 weeks gestation	0 to 6 months
CXI *	Early Cupisnique	NA	2 at 39 weeks; 1 at 35 weeks gestation	2 at 0 to 6 months; 1 below table limit

NA = not available

* Commingled remains of three infants

Porotic Hyperostosis

Active porotic hyperostosis was not observed in the children or infants of the Early Cupisnique population. One infant (one of three infants in interment CXI) had healed disease. The only interment showing active disease at the time of death was an elderly female (interment XXXVI), perhaps suggesting chronic illness, reduced food intake or reduced food quality in old age. A young adult female (interment LXXXVIII) showed evidence of both active and healed disease, the vault lesions showing healing the orbital lesions still active. Table 4.5 summarizes these results. Each frequency represents the proportion of individuals with the disorder in each age group.

Table 4.5 - Frequency of Porotic Hyperostosis *

Culture	Infant			Child			Adult			Overall			Male to Female Ratio
	n	N	%	n	N	%	n	N	%	n	N	%	
Early Cupisnique	1	3	33	0	2	0	7	9	78	8	14	57	3:4
Classic Cupisnique	1	5	20	2	3	67	5	8	63	8	16	50	0:4 **
Salinar	2	3	67	0	5	0	15	18	83	17	26	65	10:5

n = number of individuals with porotic hyperostosis

N = total number of individuals in this age class

* vault and orbital lesions combined

** sex determination was not possible for one individual

Bone Infection and Tumours

From the Early Cupisnique phase there was one individual (interment XXXII), an elderly female, with punched out lesions of the cortex of the right tibial diaphysis. There was also destruction of the left atlanto-axial joint and left side of the dens (Figure 4.2). The disease removed the cortical and subchondral bone revealing the underlying trabeculae. Also present was a "bubbly" appearance of the proximal inferior aspect of a first metatarsal. The "bubbles" were up to 2 millimeters in diameter and were surrounded by thickened cortical bone. The subchondral cortex at the proximal metatarsal joint surface appeared normal. The differential diagnosis for this condition would be multiple myeloma or metastatic disease from an unknown primary cancer or systemic infection. Infection seems more likely since metastases from cancer rarely affect joints (Greenfield, 1980), however, Dr. Elera Nuñez, a Peruvian radiologist, suggested multiple myeloma based upon his X-ray analysis of the tibia. Greenfield (1970) noted that metastatic carcinoma affects, in descending order, the axial skeleton, skull, sacroiliac joints and then the extremities. There may have been more than one disease process in this individual. Of incidental note was calcification of the posterior longitudinal ligament.

Inflammatory Arthritis

The inflammatory arthritic disorder was associated with marginal erosions of the joints of tarsals, metatarsals, carpals, metacarpals and proximal phalanges of the hands and feet (Figure 4.3). Figure 4.4 shows the appearance of the erosions. In the Early Cupisnique population adults of all ages had this disorder with a sex ratio of 3:4 females to males. The frequency of this disorder in this population was 50%. This arthritis was only evident in adults.

Interment XLIV also had cystic changes on the anterior of the proximal right humerus along the joint line on the greater tuberosity, proximal bicipital groove and lesser tuberosity (Figure 4.5). The left humerus has one large erosion superior to an area of postmortem damage. The erosion has smooth walls, while the damaged area has irregular sharp edged margins.

Interment LXXXVII was notable because there were erosions of the odontoid process of the axis (Figure 4.6) as well as phalangeal lesions. This pattern is strongly suggestive of rheumatoid arthritis (Greenfield, 1980; Rodnan and Schumacher, 1983). None of the other inflammatory arthritides have this particular pattern of inflammatory lesions.

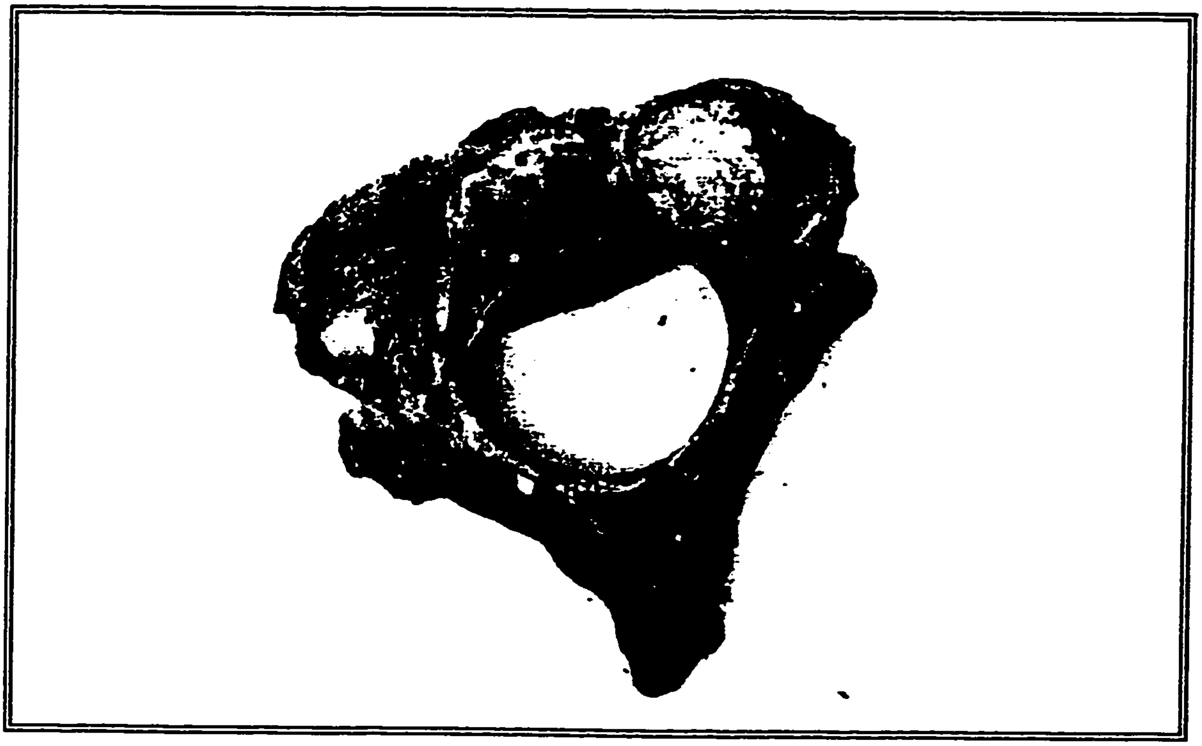
Bilateral calcaneal spurs were present at the origin of the plantar aponeurosis in interment XXXVI and on the left calcaneus in LXXXVIII. Both were females, XXXVI an elderly woman and the other a young adult. These spurs have been associated with the spondyloarthropathies, in particular ankylosing spondylitis, Reiter's syndrome and psoriatic arthritis (Rodnan and Schumacher, 1983).

Osteoarthrosis

The most commonly affected articulations, in descending order, were the spinal zygapophyseal joints, lumbar intervertebral discs, proximal and distal humeri, patellae and thoracic intervertebral discs (Figure 4.7). After these five, the distal femur, proximal radius, proximal ulna, glenoid fossa, carpals and cervical intervertebral discs were all equally frequently affected.

Cuneiform-metatarsal defects occurred in all three populations studied. Regan and Case (1997) consider this condition a partial tarsal coalition, a developmental defect under genetic control. Interment XXXV was the only individual of Early Cupisnique affinity with this condition. The frequency was 9.8% overall, 6.7% for the Early Cupisnique population sample. These need to be considered minimum frequencies since not all cuneiform-metatarsal joints were available for analysis.

Figure 4.2 Atlas and Axis of Interment XXXII



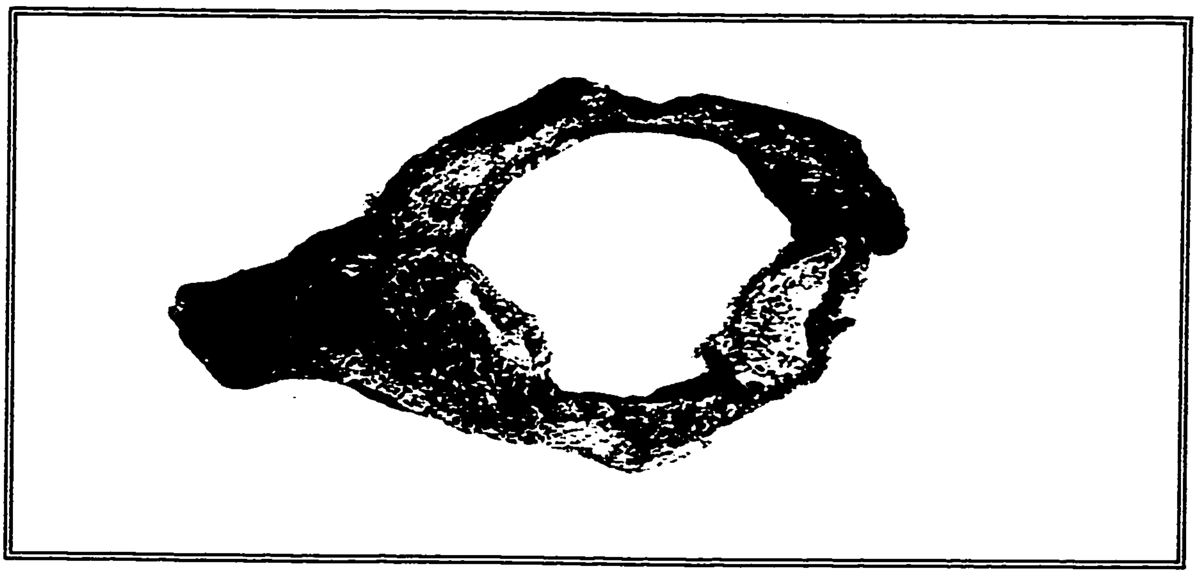


Figure 4.3 - Joints Affected by Erosive Arthritis

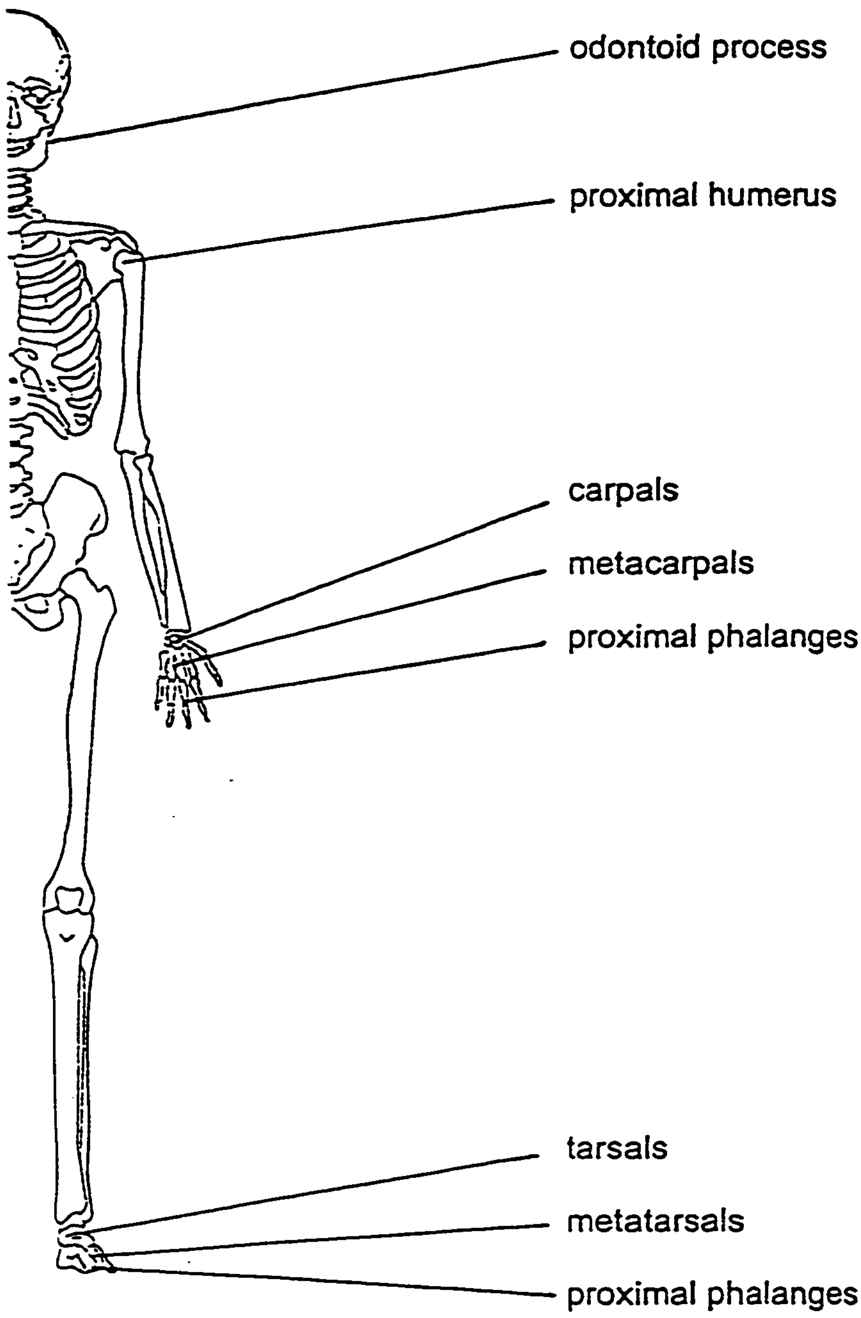
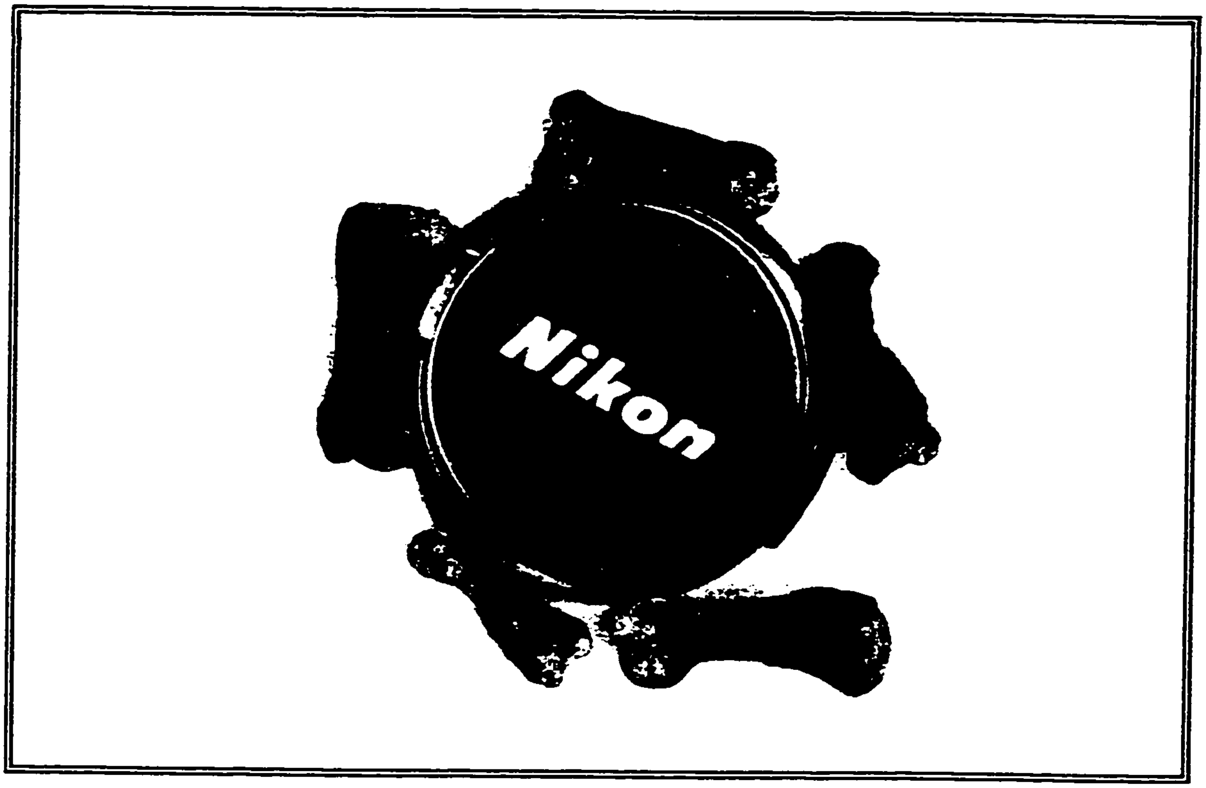


Figure 4.4 - Appearance of Erosions



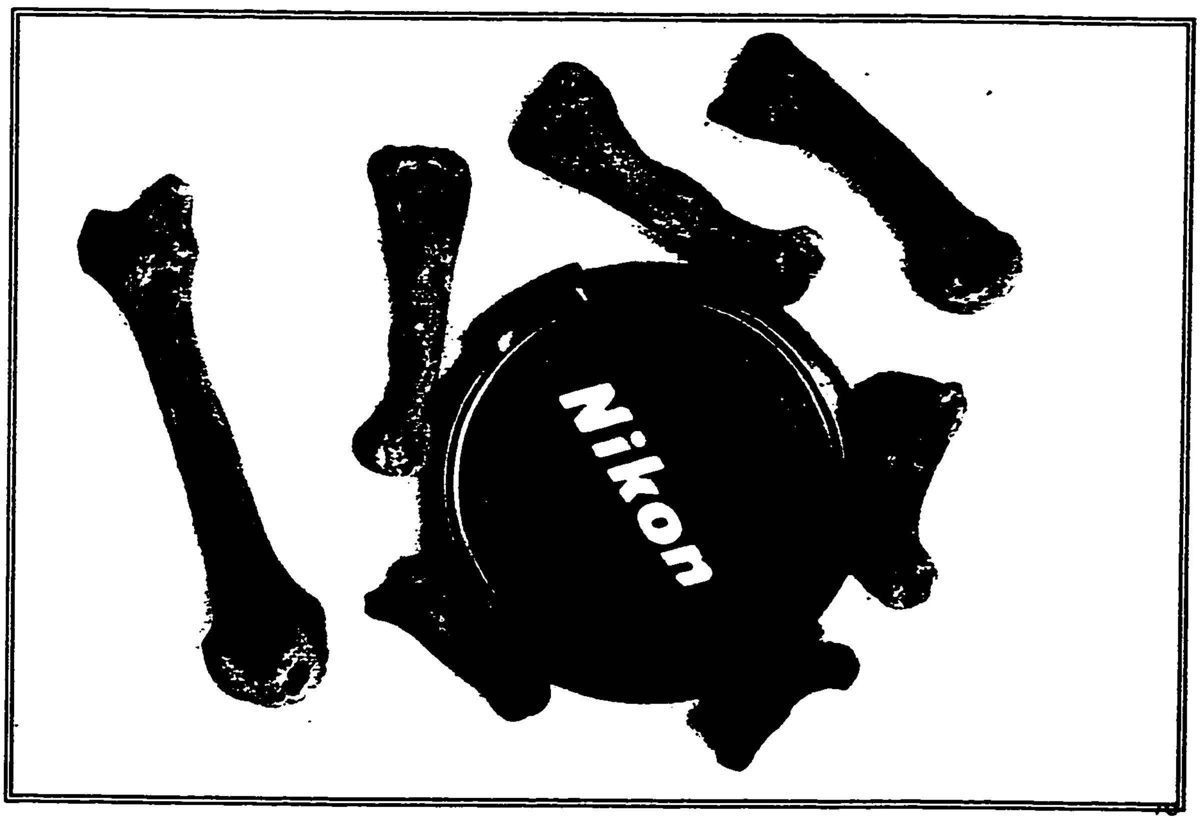


Figure 4.5 - Erosions of Right Proximal Humerus

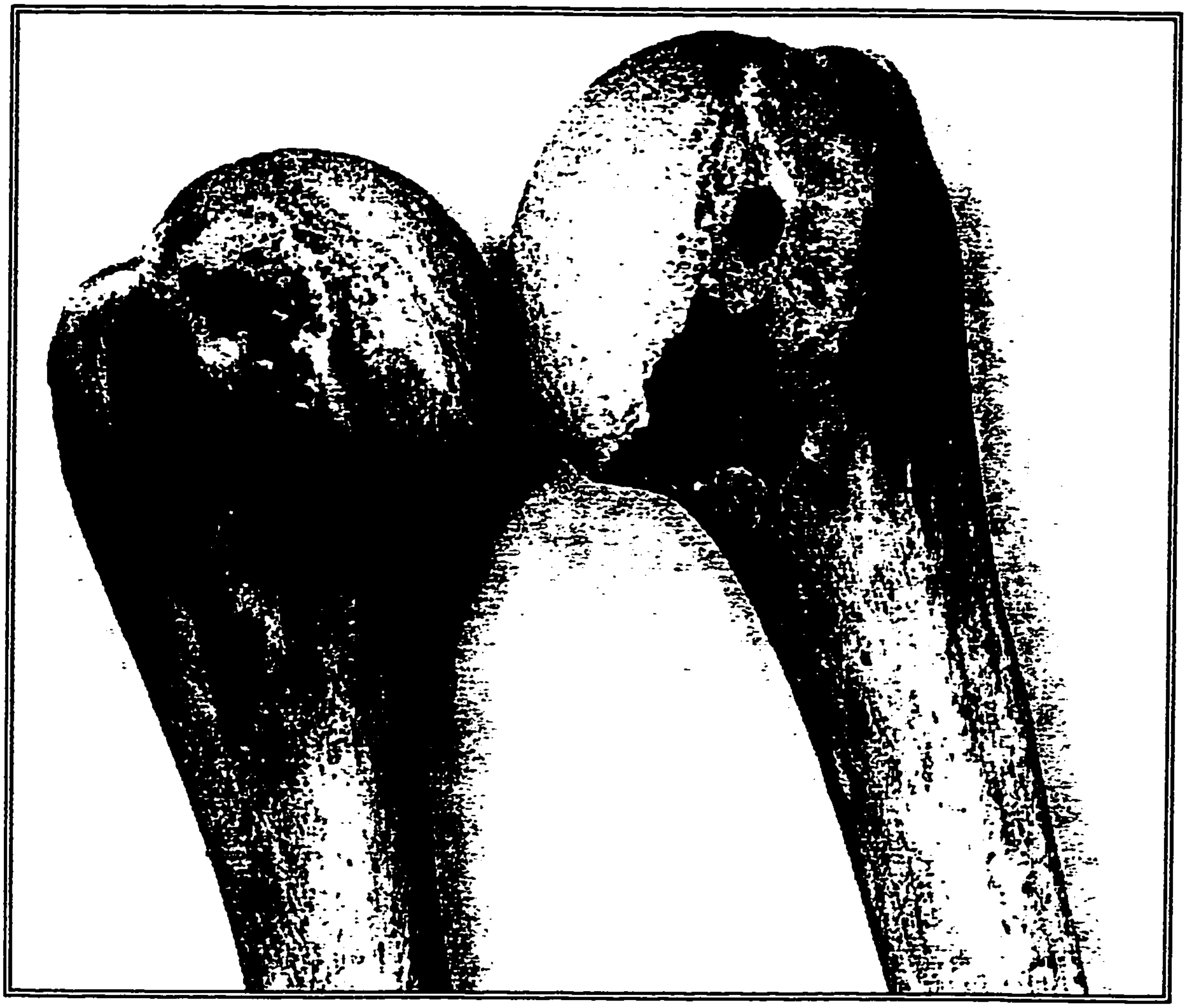
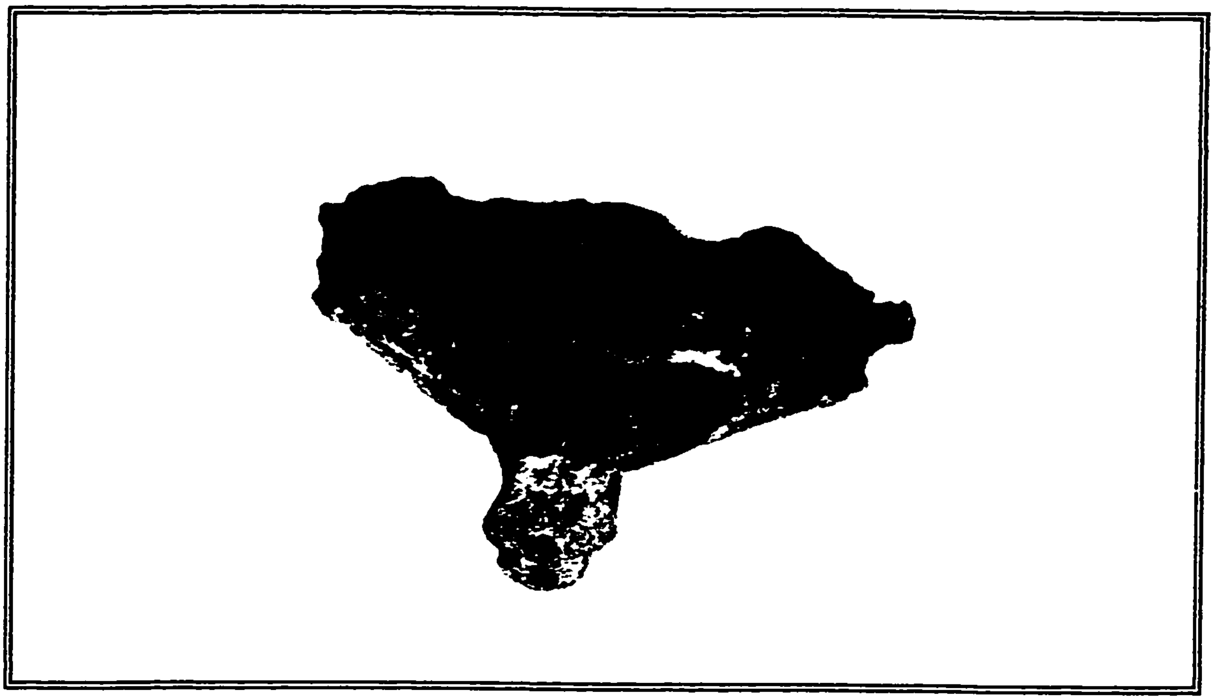


Figure 4.6 - Erosions of Odontoid Process of Axis



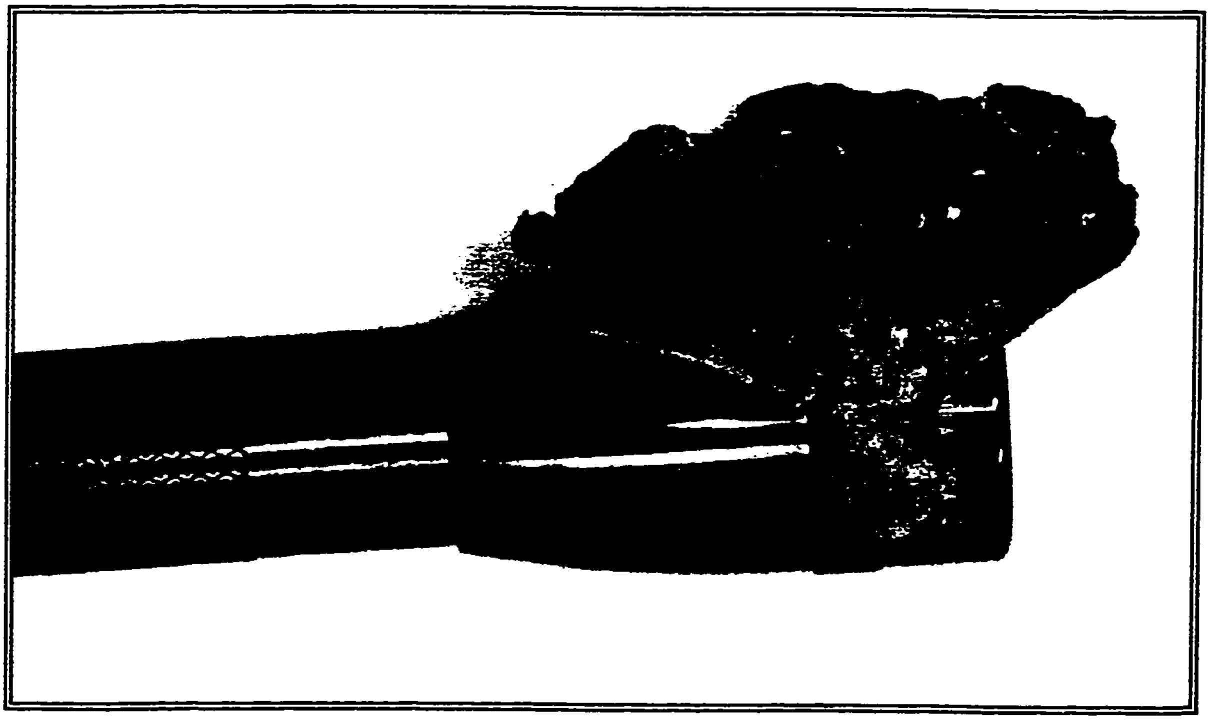
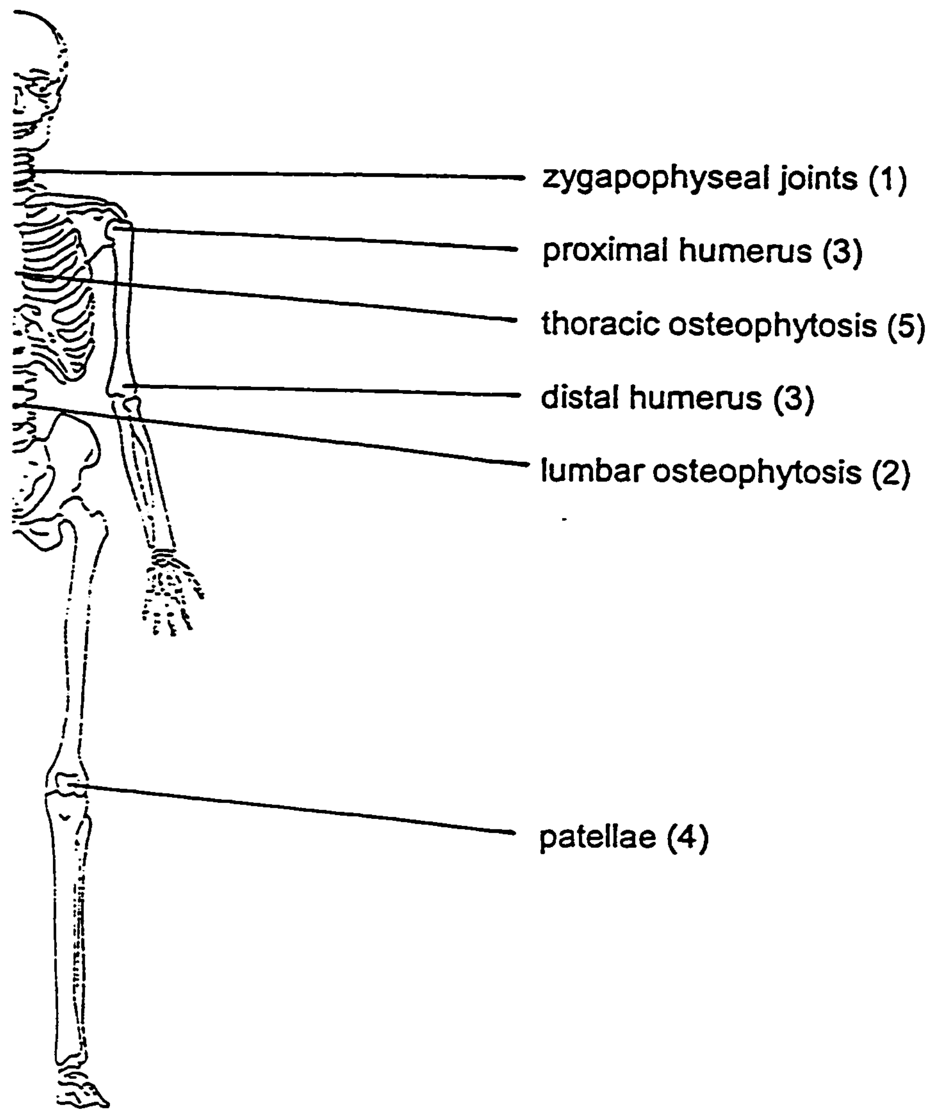


Figure 4.7 - Pattern of Osteoarthrosis in the Early Cupisnique Population



Trauma

The only evidence of trauma was a fracture of the left tibia in interment CXIII. The fracture was oblique with some over riding. The fracture was well healed. This interment was that of a young adult male.

Dental Attrition and Pathology

Molar attrition was highest during the Early Cupisnique phase at Puémape. Table 4.6 summarizes these results. Rates of anterior tooth (incisors and canines) wear and rates of caries and abscesses are similar to those in the subsequent Classic Cupisnique phase. Frequencies of caries and abscesses are the percentage of individuals demonstrating these lesions. Abscesses were consequent to the severe dental attrition. Facets were noted on the lingual surface of the incisor crowns of interment CXIII.

Table 4.6 - Frequency of Dental Disease

Culture	Caries (%)	Abscesses (%)	Average Incisor and Canine Attrition *	Average M1 Attrition *	Average M2 Attrition *
Early Cupisnique	26	16	5.8	9.0	7.4
Classic Cupisnique	19	19	3.8	7.3	6.0
Salinar	63	25	5.5	6.8	4.8

* Average for young adults according to scales of attrition in Buikstra and

Ubelaker 1994. Scales are from 1 (barely perceivable or no attrition) to 10 (all enamel gone, dentine exposed and wear extends to root).

Classic Cupisnique Osteology

Age Estimation of Infants and Children

Dental and long bone age estimates are outlined in Table 4.4. Of the Classic Cupisnique infants, interments CII and XXVII died as neonates with their ages derived from dentition (Ubelaker, 1989) and long bone lengths (Scheuer, Musgrave and Evans, 1980) in agreement. Interment XCVI lacked dentition but falls within the same age at death range according to long bone length.

When dental age (based upon Ubelaker, 1989) and long bone derived age at death (based upon Gindhart, 1973 and Scheuer *et al.*, 1980) are compared for Classic Cupisnique interments XXIX, XXX and CI, there is evidence of growth retardation. The age estimates based upon a North American Native population (Ubelaker, 1989) overlap the estimates from dental age as well as those from the European and Euro-american populations. This is because of the wider age interval for each measure of long bone length in Ubelaker's chart. Consequently, the evidence of growth retardation disappears.

Harris Lines

In this population Harris lines were found in one infant, two children, two young adult females, one young adult of indeterminate sex, one elderly adult female and one adult of unknown age and sex. In this population Harris lines were evident in femora and tibiae. The number of lines recorded for this population varied between 1 (the infant) and 11 (the adult of unknown age and sex). Both of the children had 8 lines (my counts).

Porotic Hyperostosis

Active porotic hyperostosis was evident in two of three children (interments XXII and XCIX) and one of five infants (interment CI). Unlike the Early Cupisnique sample there were also two adults with recent evidence of disease (interments XXVI and LVIII). The young adult female (interment LVIII) shows some evidence of healing. A summary of these results are in Table 4.5.

Bone Infection and Tumours

Infection was evident in two individuals from the Classic Cupisnique population. The adult in interment XXVIII had an intermediate phalange that was expanded throughout the distal third. The cortex is irregular over the enlargement which projects laterally. The appearance is of a slowly developing osteomyelitis that led to periosteal elevation and new bone formation.

Interment CXVIII contained three adult right femora. One had a fusiform enlargement on the medial aspect half way down the shaft. There was also a very prominent linea aspera.

Inflammatory Arthritis

The population frequency of this disorder was 9%. The only individual with the inflammatory arthritis (interment LXII) was an adult from a multiple interment and could not be accurately aged or sexed.

Osteoarthrosis

The skeletal series was not very complete for this population, however, in descending order, the five most common sites of osteoarthrosis were lumbar intervertebral discs, spinal zygapophyseal joints and the distal humerus, proximal ulna and proximal radius equally (Figure 4.8).

Interment XXI from the Classic Cupisnique population had the cuneiform-metatarsal defect. The frequency was 9.8% overall, 4.8% for Classic Cupisnique population sample. These need to be considered minimum frequencies since not all cuneiform-metatarsal joints were available for analysis.

Trauma

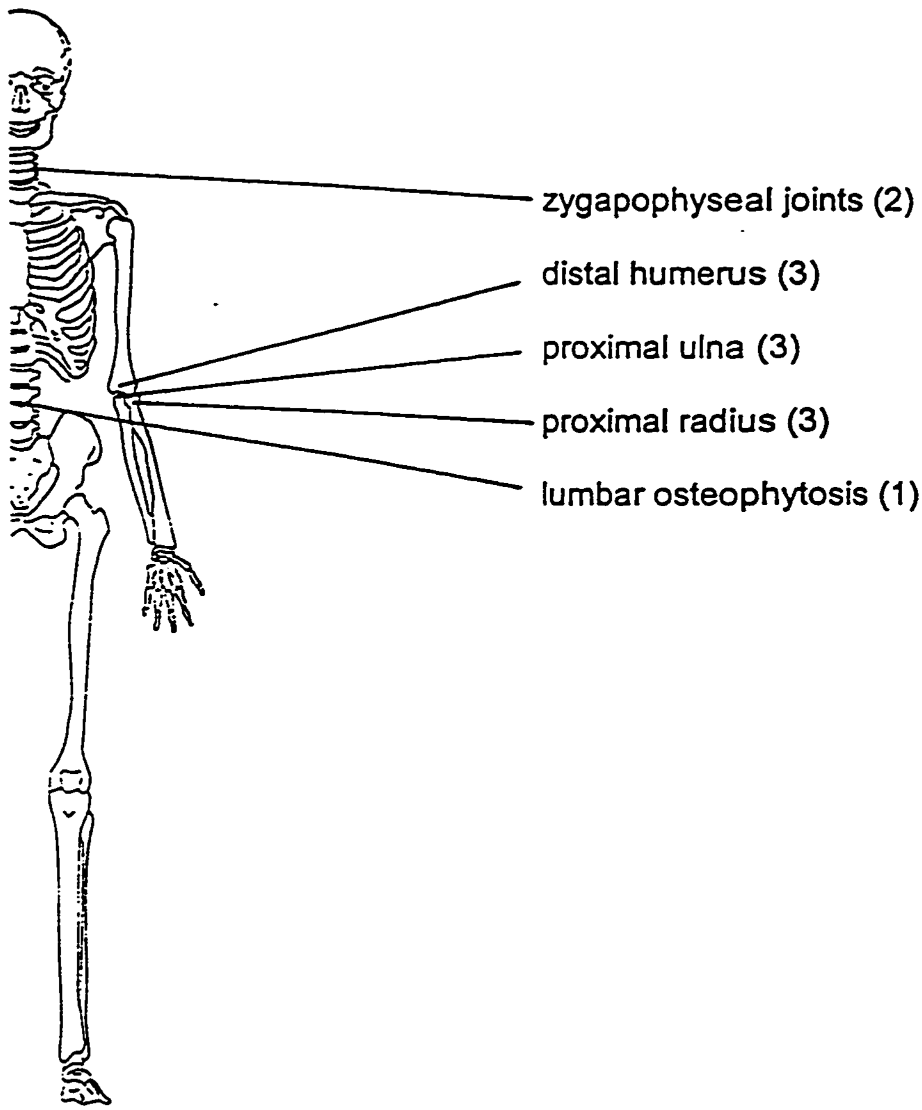
The singular evidence of trauma was a fracture of a metatarsal shaft in interment CIII. This interment was that of an adult of unknown age and sex. The fracture had healed with angulation.

Dental Attrition and Pathology

Dental hypoplasia was noted in interment XC which had a broad band of pitting hypoplasia across a permanent incisor. This child was seven years of age at death.

Dental pathology is outlined in Table 4.6. Overall it appears that the population from this cultural phase were intermediate to the other two cultures for most conditions. For caries and abscesses they were most like the Early Cupisnique population, while dental attrition was most like the Salinar population. Lingual facets were noted on the incisors of interment CIX. These had the same appearance as those described for the Early Cupisnique phase interment.

Figure 4.8 - Pattern of Osteoarthrosis in the Classic Cupisnique Population



Salinar Osteology

Age Estimation of Infants and Children

Dental age and long bone age determinations for infants and children from the Salinar population are in Table 4.4. These results echo those for the Classic Cupisnique population since these children also showed growth retardation at the time of their death compared to the populations used by Gindhart (1973) and Scheuer *et al.* (1980). The age at death based upon long bone length was in agreement for all three methods, with two exceptions. Interment XVI was younger according to Ubelaker's standard than Gindhart's. Unfortunately, the dentition was missing for this particular interment. The other exception was interment LXXXI who was the only individual showing stunting according to all estimates of age from long bones.

Harris Lines

In the Salinar population there were individuals of all age groups and both sexes with Harris lines. These lines were evident in femora, tibiae and humeri. For most of these individuals the number of lines was not recorded; however, for one male young adult there were four lines and in one child there were eleven (Dr. Elera Nuñez's counts). I noted one line in one other child. In total one infant, three children, five young adult males, two young adult females, four middle aged males and one elderly female had Harris lines. One adult of unknown age and sex also had at least one Harris line by Dr. Elera Nuñez's count.

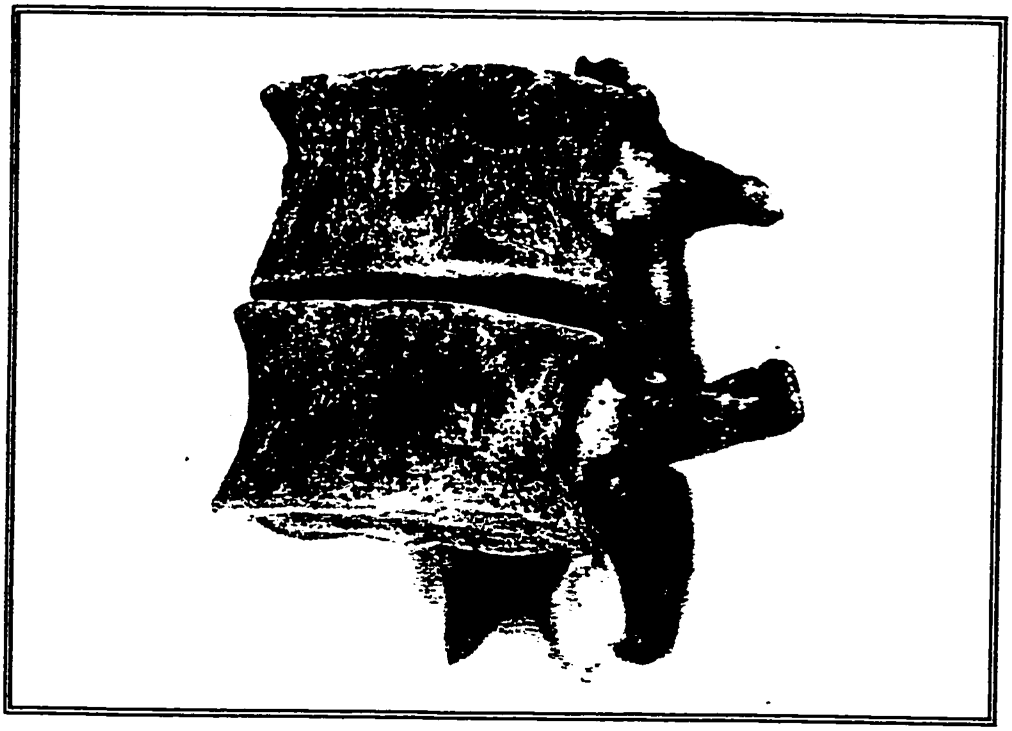
Porotic Hyperostosis

The Salinar population sample showed active porotic hyperostosis in two of three infants (interments XLVI and LVII). One male young adult (interment XLIII) had active disease. Young adults (interments XI, XXXIX) and a middle aged adult (interment LIII) had mixed disease with some healing. Interments XI and LIII were male and XXXIX was female. Healed disease was evident in all adult age groups. Table 4.5 summarizes these results.

Bone Infection and Tumours

Interment LXVII, a young adult Salinar male, had punched out cortical lesions in the bodies of the vertebrae from the tenth thoracic vertebra down to the fifth lumbar vertebra (inclusive). Figure 4.9 shows these lesions in two vertebrae. These lesions were smooth walled suggesting a slowly advancing disorder. There was also expansion of the proximal right fibula medio-laterally. The cortex of the fibula appeared normal. This pattern is suggestive of osteonyditis.

Figure 4.9 Lesions in Lumbar Vertebrae of Interment LXVII



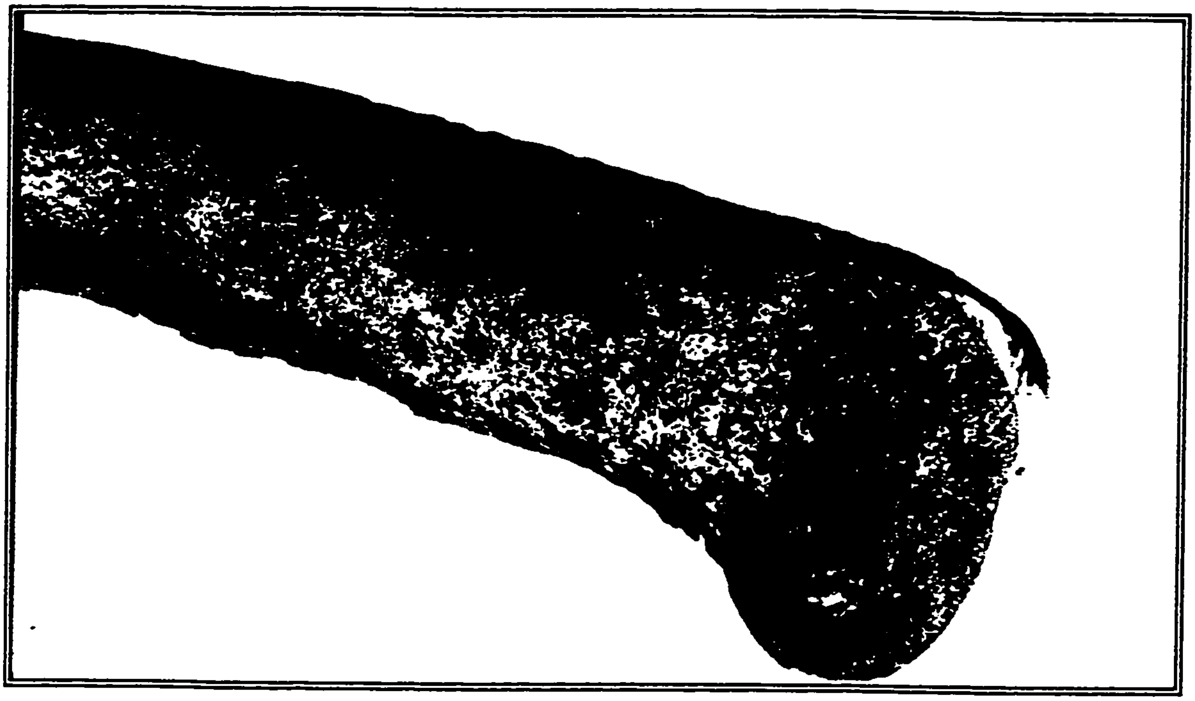
An elderly Salinar female (interment XIII) had expansion (increased diameter) of a femur (Figure 4.10), humerus and ribs. Metastatic disease is unlikely since bone proliferation is not common with a carcinoma. A possible site of a primary carcinoma is breast, spreading directly to the ribs (Chapman and Nakielny, 1984). Osteomyelitis or direct metastases of tuberculosis from the lungs to ribs is more likely. Dr. Elera Nuñez, a Peruvian radiologist, suggested osteomyelitis of all the involved bones based upon his radiographic analysis.

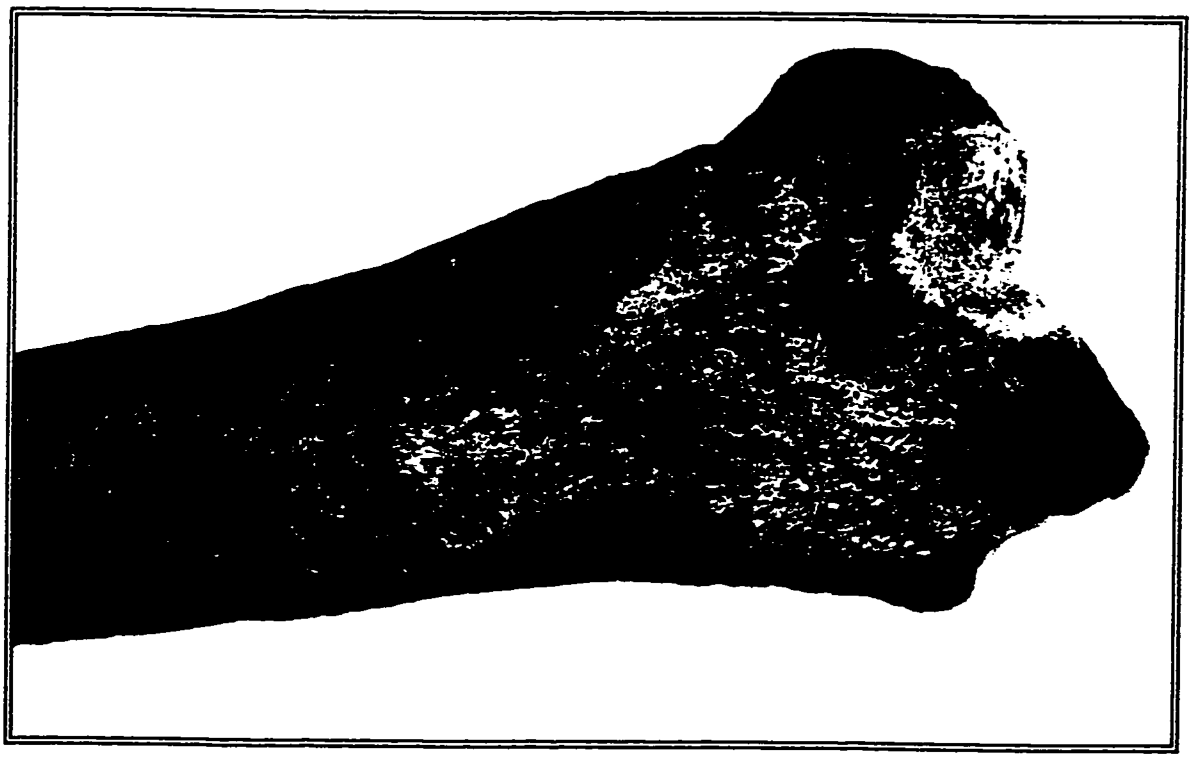
Interment IV, V, VI, VII included a tibia with an enlargement on the distal posterior surface ten millimeters above the lateral limit of the medial condyle. It measures eight millimeters in height above the cortex, and 25 millimeters along the bone long axis by 15 millimeters in width. Its cortex appeared normal.

Also from this interment was a left clavicle with expansion of the medial inferior surface measuring 22 millimeters along the clavicle's long axis by 12 millimeters. It was raised 3 millimeters above the cortex and covered by wavy cortical bone of the same appearance as subchondral bone.

One metacarpal from the same interment had "bubbly" cortical lesions just distal to the proximal joint surface. These lesions were on the medial, superior and lateral surfaces of the bone. The joint surface was not involved. They had the appearance of resorptive foci with subsequently reactive bony sclerosis so that the "bubbles" became lined with compact bone. The differential diagnosis was an erosive arthritis.

Figure 4.10 Expansion of Femur in Interment XIII





Salinar interment X, a middle aged male, had woven bone overlying an expansion of the medial aspect of the distal one-third of the left fibula.

Interment XXXIX, a young adult male of Salinar affinity had expansion of the distal femora, a tibia and fibula, a humerus and radius. The femora were expanded over the distal posterior one-quarter. The posterior distal one-third of the right tibia was expanded as was the entire right fibula. The expansion of the left radius was throughout the distal one-third of the shaft. Left humerus expansion was in the posterior distal one-half.

Salinar interment XL, a young adult male, had changes in his tibiae and fibulae. The left fibula had cystic lesions in the distal anterior shaft extending 27 millimeters up the shaft. The right had an expanded distal shaft, and a mushroom shaped medial expansion that articulated with the tibia. There was an overall expansion of the distal two-thirds of the shaft with coarsely woven bone on the medial surface. The left tibia had a discrete expansion 58 millimeters above the medial malleolus measuring eleven by eight millimeters and two millimeters above the cortical surface.

Interment XLV, a middle aged female of Salinar cultural affinity, had antero-posterior bowing of her tibia with an increased antero-posterior dimension.

A young adult Salinar male (interment LXVI) had cortical bone thickening of the anterior left tibia. The right femur had a distal posterior periosteal elevation with woven bone laid down.

The diagnosis of bone infection for these individuals was reached by considering the pattern of bone involvement and changes in the affected bones. Generally, lytic metastases from a cancer are aggressive and lead to loss of trabecular and cortical bone (resorption) without time for an inflammatory response from the bone (Greenfield, 1980). In contrast, osteomyelitis is less aggressive and bone inflammation and proliferation ensues. The result is bone expansion and periosteal reaction to the infection. *Staphylococcus aureus* is associated with 75% to 80% of these infections, β-hemolytic streptococcus being the next most likely infectious agent (Berkow, 1982).

Inflammatory Arthritis

Erosive arthritis was evident in one Salinar interment (Interment IV, V, VI, VII) which was the commingled remains of nine individuals. There was osteoporosis of the involved skeletal elements. There was fusion of the right talus and calcaneus by fine enthesopathy medially (Figure 4.11). Laterally there was no enthesopathy and the joint space appeared to be maintained. There was fusion due to enthesopathy affecting two cervical vertebrae. They were fused by vertical marginal enthesopathy across the intervertebral disc space and left zygapophyseal joint (right side joint missing). Five thoracic vertebrae were fused in the same fashion (Figure 4.12). There was also costotransverse and costovertebral fusion in this fused thoracic segment. The enthesopathy was marginal and fine in structure. Although unproved, I believe that these skeletal elements are from one individual. This pattern matches that of ankylosing spondylitis (Greenfield, 1970).

Interments from the Salinar culture with bilateral calcaneal spurs were XLV, XL and LXIX. Interment XL represents a young adult male, LXIX a middle aged male and XLV a middle aged individual tentatively identified as female.

In the Salinar population the sex ratio for the inflammatory arthritis was 4:7 females to males. The frequency of this disorder, in this population, was 65%. In the multiple burial (interment IV, V, VI, VII), that had the putative example of ankylosing spondylitis there was also a metatarsal with marginal joint erosions. Unfortunately, distinguishing the original owner of the metatarsal is impossible.

Osteoarthrosis

In descending order the five most common sites for this form of arthritis were phalanges, lumbar intervertebral discs, spinal zygapophyseal joints, costovertebral joints and proximal radius equally and metacarpals and thoracic intervertebral discs equally (Figure 4.13).

Interments X, XL, L and LXXIV had the cuneiform-metatarsal defect. The defect was equally present in males and females. The frequency was 9.8% overall and 16% in the Salinar population sampled. These need to be considered minimum frequencies since not all cuneiform-metatarsal joints were available for analysis.

Of interest were two males from the Salinar population (interments X and XLVII) that had kneeling facets (described in Ubelaker, 1979). In contrast to the coastal Ecuador population at Ayalan, where these facets were noted in females, these changes were evident in Salinar males. It is not clear what this means in terms of Salinar lifestyle.

Trauma

Tables 4.7 summarizes the evidence of trauma. Those in interments XI, XIII, XLIII, LIII and LXVIII were healed fractures of various long bones. The other set, represented by XLV, LXXVI, LXXIV and LXIX, suggests major compressive forces on the spine as well as extremity injury, perhaps from falls.

Of the skeletons showing axial compressive injuries all but one were male (and for XLV, female is an equivocal designation). The only traumas that could possibly be attributed to interpersonal violence was the ulnar fracture (Parry fracture) in XLV, a putative female from the Salinar culture. Interment LXXVI also had a cut into the lateral side of the left orbit made when still alive. There was evidence of healing of the injury. Whether this was due to a violent act or accident is not clear.

Figure 4.11 Fusion of Talus and Calcaneus by Enthesopathy

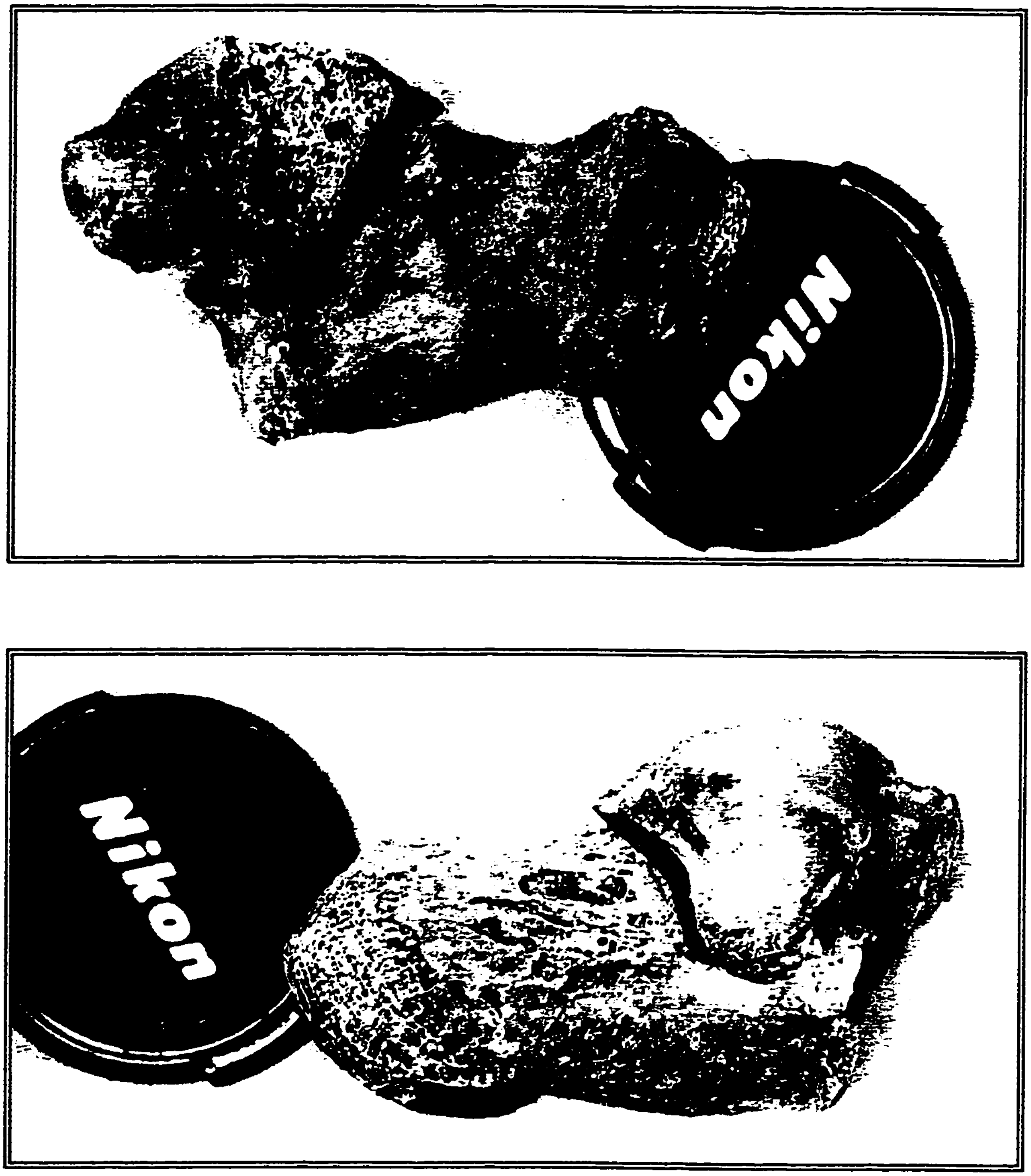


Figure 4.12 Fusion of Thoracic Vertebrae and Costovertebral Joints by Enthesopathy

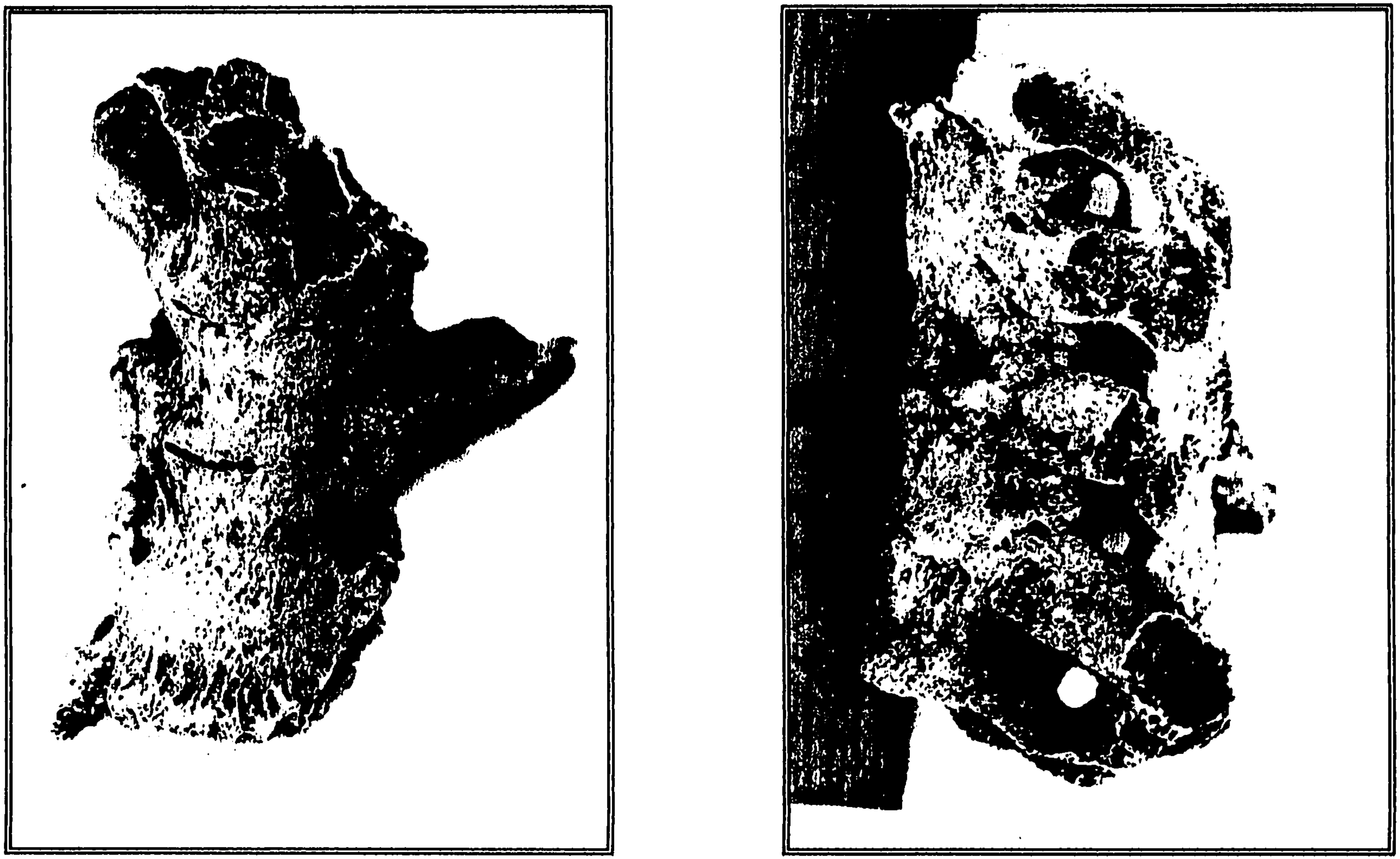


Figure 4.13 - Pattern of Oseoarthrosis in the Salinar Population

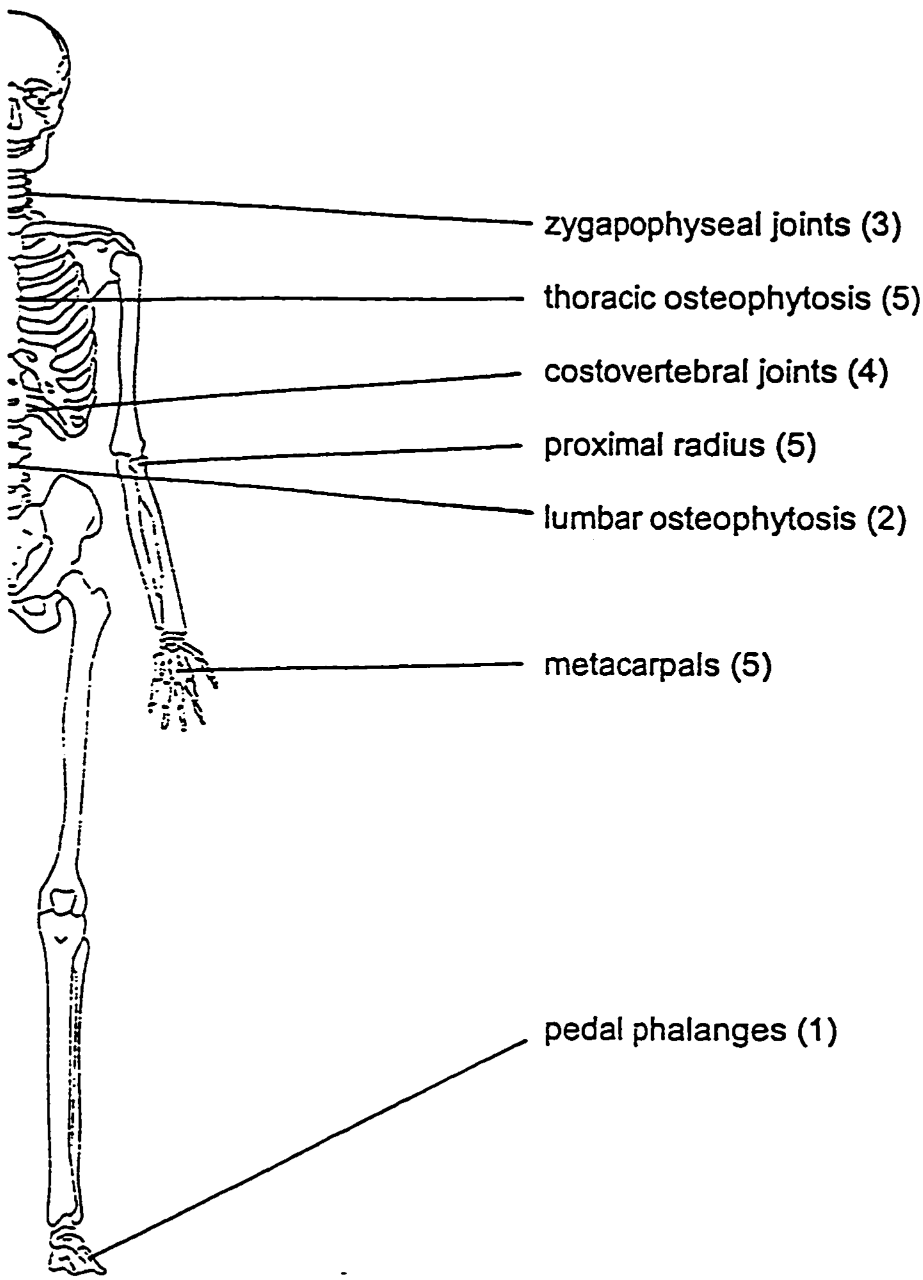


Table 4.7 - Trauma During the Salinar Cultural Period

Interment	Trauma
XI	oblique fractures of left radius with angulation, two pedal phalanges: all healed
XIII	oblique fracture of metacarpal shaft: healed
XLIII	oblique fracture of shaft of left fibula: healed
XLV	oblique fractures of pedal phalange and left ulna, compression fracture of L3: all healed
LIII	oblique fracture of shaft of right ulna: healed
LXVIII	oblique fracture of shaft of pedal phalange: healed
LXIX	compression fracture of L1: healed
LXXIV	oblique fractures of shafts of pedal phalange, metacarpal, compression fracture T12, left tibial plateau fracture: all healed
LXXVI	compression fracture C5, fracture of left zygomatic process of maxilla, cut in left lateral aspect of orbit: all healed

Two of the Salinar interments (LXVIII and LXVII) were buried headless. Whether this was due to a traumatic event or postmortem decapitation is not clear.

Dental Attrition and Pathology

Dental hypoplasia was evident in interment LXXVII which showed linear hypoplasias across the central and lateral incisors. This individual died in childhood and the age at death and stature at death could not be determined.

Table 4.6 outlines dental pathology. Molar attrition was lowest during this cultural period. The frequency of caries and abscesses were the highest during this period. Caries frequency (persons with caries as a percentage of the entire population sample) doubled that of the preceding Cupisnique cultural phases. Lingual facets, identical in appearance to those found in the Early Cupisnique and Classic Cupisnique phases were evident on the incisors of interment LXIX.

Chapter 5 - **Discussion**

This chapter will follow the same format as Chapter 4 (Results). First, the growth of infants and children will be a considered, followed by a consideration of Harris lines, believed to indicate growth perturbation. Linear enamel hypoplasia will be considered with the discussion of dentition. Porotic hyperostosis, an indicator of health and nutrition, will then be discussed. After these considerations, which primarily affect subadults, bone infection and tumours will be considered. Next the arthritic processes will be discussed followed by trauma and dentition. In addition, comparison will be made with populations from the Northwest Coast of North America as well as Ecuador.

Since the sample sizes are small and biased by cultural factors and the nature of the excavation (as discussed in Chapter 4), the data and interpretation in this study are not expected to be entirely representative of the populations at Puémape. Therefore, my interpretation of behavioural change during the course of the Cupisnique cultural complex and Salinar culture is tentative and await further study for confirmation (or rejection).

Age Estimation of Infants and Children

Huss-Ashmore *et al.* (1982) discussed a number of skeletal indicators that revealed the presence or absence of diet related pathology. One of these is the change in growth attributed to nutritional stress. In the present study the correlation of long bone length to dental age revealed that the methods of Gindhart (1973) and Scheuer *et al.* (1980) indicated the presence of stunting in the children at Puémape during the Classic Cupisnique phase and Salinar culture. (None of the Early Cupisnique infants or children were complete enough to do this analysis.) Only one interment (LXXXI) was of limb proportions that matched that of Gindhart's source population (Table 4.4). The others appeared considerably stunted. These included interments XXIX, XXX, XLVI, LVII, LXIII and CI. All were, by bone length, estimated to be at least three months younger than their dental age at death. Either they were severely malnourished or the growth trajectory of this population was significantly different from Gindhart's source population. Her study population was "white, middle class and of northwestern European descent" (page 42).

The findings of this study echo those of Lampl and Johnston (1996). They found that in a Mexican population "130 children of skeletal age between 39 and 44 months are actually between 4 and 7.4 chronological years of age" (Lampl and Johnston, 1996: 345). This can be compounded with the previously known error in comparing dental age with chronological age (they state up to 100% difference in a sample of Canadian children). In their study, Lampl and Johnston stated that their Mexican population was a "population living under conditions of environmental stress with chronic mild to moderate protein-energy malnutrition and moderate to high levels of infectious disease" (Lampl and Johnston, 1996: 345). They suggest that this Mexican population can be used as a proxy for past populations that lived with these stresses. Certainly, the stunting of growth matched that of the children from Puémape.

Other prehistoric and protohistoric populations have been observed to have slower rates of growth than European standard populations. Y'Edynak (1976) in her consideration of Alaskan Inuit and Aleut found that growth was less than the standard population and that the growth differences were evident from an age of less than one year. Johnston (1962) studied the Indian Knoll skeletal population with similar results. He concluded that the growth curve differences were detectable by two years of age and that this variation from the European standard was environmental in origin. In a paper by Merchant and Ubelaker (1977) they stated that the growth curves they derived for the Arikara were almost identical to those for Indian Knoll. They concluded that over the four millennia between these populations that the growth rates of native North American peoples did not change significantly. This is also significant since one group (Indian Knoll) were hunter/gatherers while the Arikara were agriculturalists.

Ubelaker (1989) developed a table for determining age from long bone length based upon the protohistoric Arikara skeletal series. Using these data the stunting seen at Puémape disappears. Therefore, the populations at Puémape seem to have the lower growth rate evident in other Native American populations.

Harris Lines

Radiographs of the skeletal series were interpreted by Dr. Elera Nuñez, a Peruvian radiologist, and myself. Figure 4.5 compares our findings of Harris lines. Clearly, there is a significant difference. Dr. Elera Nuñez and I agreed in only five instances. I identified Harris lines in one instance that he did not and he recognized them in twenty instances that I did not. The reasons for this disparity can be understood in the light of our differing methodology, outlined in Chapter 4, and in the content of two papers. These are the papers of Macchiarelli *et al.* (1994) and Grolleau-Raoux *et al.* (1997). They noted that both intra and inter-observer error is considerable when counting these lines. Also, I did not have access to a light box, nor did I use a magnifier, as used, for example, by Grolleau-Raoux *et al.* (1997).

However, the results of this study agreed with their findings regarding the presence of these lines in adults. Typically, young adults have the highest number of Harris lines, the number of lines decreasing with age (Larsen, 1987). Dreizen *et al.* (1964) suggested that individual bones in the developing skeleton have the greatest sensitivity to insult at the age they reach their maximal growth rate. This would support the view that growth rate is very important to the development of Harris lines and that interbone comparisons are not advisable. However, by comparing the frequency of Harris lines between bones within an individual or between individuals, the timing of maximal growth rate or maximal disease stress may be discerned.

Dr. Elera Nuñez and I both identified Harris lines in infants, children and adults. As previously observed by Larsen (1987) older adults had relatively fewer Harris lines. This is believed due to the remodeling process removing Harris lines over the years. In this study, this is born out in that two of eighteen infants (11%), six of twenty-six children (23%), ten of twenty-three young adults (43%), three of eleven middle aged adults (27%) and two of seven (29%) old adults had Harris lines. These findings do not match the expected childhood peak in frequency described in the review by Huss-Ashmore *et al.* (1982). Such a pattern was evident in both Anglo-Saxon and North American Native populations.

Curiously, 11% of infants had Harris lines which Grolleau-Raoux *et al.* (1997) considered a rare finding. This may represent insufficient maternal nutrition (Steinbock 1976) or a disease process going on during pregnancy (Sontag, 1938) as reviewed in Grolleau-Raoux *et al.* (1997).

Magennis (1990), in her analysis of 104 boys and girls found that Harris lines were statistically related to high growth rates. Such periods of rapid growth may be a consequence of rapid normal growth or catch up growth after nutritional insult or major disease. It is difficult, if not impossible in archaeological contexts, to determine which of these lead to the development of Harris lines. Hummert and Van Gerven (1985) considered a Sudanese Nubian population and had results in support of this interpretation. The age classes showing the most new lines were those with the highest rates of growth.

Such a view would offer an alternative view of the results of the study by Allison *et al.* (1975). They argued that fewer Harris lines in Andean people indicated better health than was the case for coastal populations. This would be in agreement with Walker (1986) for native peoples of the California coast. Limited sources of fresh water, high population density and a diet consisting of uncooked marine fish and mammals led to a high parasite load, diarrheal disease, anemia and slower growth for the coastal versus inland peoples. The opposing view would suggest that the coastal Peruvians had higher incremental growth rates at certain ages than the highland people. This is not unreasonable since highland people are typically of shorter stature (Frisancho, 1993). Therefore, the higher growth rates of the coastal peoples led to a higher frequency of Harris lines regardless of health.

Hummert and Van Gerven (1985) also pointed out that the development of Harris lines could be attributed to genetic and environmental factors other than growth. They compared their results for Nubia with those for American Indians and found that the ages of maximal rate of Harris line development differed significantly. The American Indians developed Harris lines primarily in childhood while the Nubians did so during adolescence. This suggested to them that genetically determined variation in growth led to the interpopulation differences.

Two other considerations leading to within population variation in Harris lines were age and sex (Hummert and Van Gerven, 1985). Older females had relatively fewer lines than males, likely due to higher rates of bone turnover.

Another important consideration, and not often considered in interpopulation comparisons, was that comparison needed to be kept within identical age intervals to be valid. This was due to age dependent variation in bone turnover and bone growth rate.

Porotic Hyperostosis

Evidence at Puémape of poor nutritional quality or infectious disease was the presence of porotic hyperostosis. This disorder is believed to be the result of anemia in infants and children (Stuart-Macadam, 1987a, 1987b, 1989; Mensforth *et al.*, 1978; Holland and O'Brien, 1997). These papers clearly indicate that the etiology of this disorder is multifaceted and rarely the result of a single factor. Inadequate iron or unabsorbable iron in the diet as well as iron loss via a number of mechanisms including parasitism are believed to be the instigators. Maternal nutrition can be estimated also since porotic hyperostosis in early infancy suggests malnutrition of pregnant women or low maternal milk production.

Palkovich (1987) argued for poor maternal nutrition in her study of infants at the Arroyo Hondo site in the American southwest. She found infants under six months of age that had cribra orbitalia. The argument she presented was that infants under six months of age should receive sufficient iron in their mother's milk as well as have sufficient iron reserves built up during fetal life to prevent the development of this disorder. The source of iron was maternal iron stores built up before pregnancy and maternal iron intake during pregnancy. Presence of the disorder was therefore strongly suggestive of poor maternal nutrition. Since infants in the Classic Cupisnique phase and during the Salinar phase suffered from porotic hyperostosis it seems likely that maternal factors were involved.

The relationship of malnutrition to infection is well known (reviewed in Klepinger, 1992). She noted that children with kwashiorkor have high transferrin (an iron binding and transport protein in serum) concentrations and this increases their susceptibility to bacterial pathogens. This would be compounded by maternal dietary insufficiency since breast milk production or quality would also be reduced. She also reminded us that the anemia of chronic diseases does not lead to marrow hyperplasia and the development of porotic hyperostosis. Therefore, there are different factors leading to the development of porotic hyperostosis than those leading to the anemia of chronic disease.

An indication of the tangle of factors leading to porotic hyperostosis was outlined by Walker (1986). He concluded that native Americans along the California coast had a number of biological and social factors leading to the development of this disorder. These included high density living with limited access to fresh water sources, changes in oceanic currents altering the availability of marine resources and intestinal parasites from the marine fish and mammals. He linked the first two factors with contaminated drinking water and subsequent diarrheal disease. Changes in marine resource quantity may have led to prolonged breast-feeding or protein energy malnutrition. All of these or a combination of these would lead to diminished iron stores and the development of porotic hyperostosis.

In this paper, Walker (1986) noted Hrdlicka's observation that coastal Peruvians had a higher frequency of porotic hyperostosis than highlanders. He concludes that the same factors were involved in the development of this disorder in Peru as in California. Relevant factors, also present at the site of Puémape, would be high population density, limited access to fresh water, the eating of marine resources (and their attendant parasites) and regular occurrences of El Niño that led to disruption of the marine and terrestrial environment precipitating further population stresses.

In his review, Verano (1992) also echoed this theme. He noted a lower frequency of porotic hyperostosis in highland versus coastal Peruvian populations. Verano's research was based upon the frequency of this pathology at Pacatnamu, a site that spanned the Middle Horizon and Late Intermediate period. This site is situated at the mouth of the Jequetepeque valley. When compared with highland sites there was a greater frequency of porotic hyperostosis. However, there were also greater levels of porotic hyperostosis during the Late Intermediate period over the Middle Horizon. This was attributed to greater social stratification during this latter period and poorer nutrition for the general population while the elite(s) were better off. Verano (1992) suggested that the greater level of porotic hyperostosis in coastal populations perhaps relates to the earlier development of stratified societies on the coast. He also noted the wide range in frequency of porotic hyperostosis in different coastal populations.

Parasite loads, although downplayed by some (Holland and O'Brien, 1997), are relevant, as pointed out by Walker (1986). Patrucco *et al.* (1983) studied human coprolites from the north Central Coast of Peru. They found eggs of *Diphyllobothrium pacificum*, *Enterobius vermicularis* and *Ascaris lumbricoides*. All of these are intestinal parasites of humans. *E. vermicularis* are pinworms and found associated with humans world wide. *A. lumbricoides* (a roundworm) and *D. pacificum* are human pathogens and associated with significant morbidity. *D. pacificum* (a tapeworm) has as its normal host seals (*Otaria byronia*, *Arctocephalus australia*) with intermediate hosts including fish species such as the Corvina (*Sciaena gilberti*). As previously noted in Chapter 3, both seals and the Corvina were included in the subsistence of the people living at Puémape. Doubtless, just as humans become infected today (Patrucco *et al.*, 1983) they did so in pre-Hispanic times as a consequence of eating uncooked or lightly cooked fish or seal meat or through contamination of other foodstuffs after butchering seals.

However, Ramsey and Plorde (1983) indicated that Diphyllobothriasis leads to anemia in only 0.1 to 2.0 % of infected individuals. This megaloblastic anemia may be severe, however, since the tapeworm can outcompete its human host for vitamin B12. The gastrointestinal distress is not often very severe, however the neurological consequences of the vitamin B12 deficiency and toxins secreted by the tapeworm may be more debilitating. Plorde (1983) pointed out that ascariasis may have a prevalence of 80 to 90% in endemic areas and "children are almost universally infected" (Plorde, 1983: 1226). Symptoms may include gastrointestinal complaints and bronchopneumonia. Malabsorption of nutrients is a common occurrence and may lead to stunting of growth. Massive infections by either of these parasites can lead to bowel obstruction (Plorde, 1983; Ramsey and Plorde, 1983). Since parasites of this type cause relatively little anemia, a comment by Holland and O'Brien (1997) becomes relevant. They felt that dietary intake of absorbable iron may be the key factor determining whether or not anemia and porotic hyperostosis develop.

A further confounder in determining the cause(s) of porotic hyperostosis is genetic or presently idiopathic conditions that lead to anemia. Scott *et al.* (1959) looked at hemogobins in an attempt to explain the anemia common in western Alaskan Inuit. They did not find a hemoglobinopathy and therefore could not explain the clinical finding. Petersen *et al.* (1996) again looked at this problem and identified that iron deficiency anemia was more common in all ages and both sexes of Alaskan native peoples (Aleut, Inuit and Indian). Further, they did not believe there were intestinal parasites and the dietary quality of these people indicated adequate iron intake in a readily absorbable form (heme). A preliminary study indicated blood in the stools of these people. The authors then considered possible causes of intestinal bleeding and hypothesized that a high dietary intake of fish led to high n-3 fatty acid levels in their blood serum. This could lead to decreased platelet aggregation and intestinal bleeding. This does remind us that iron metabolism is complex and that, as previously stated, the development of porotic hyperostosis is a multifaceted issue.

Other west coast prehistoric New World cultures exhibited variable levels of porotic hyperostosis. Cybulski (1990) noted that the frequency of cribra orbitalia for Canadian North West Coast native populations was generally less than that for other North American native peoples. For the prehistoric period the average for the B.C. coast was 13.8% and for the early historic period 13.1%. Variation was significant in the prehistoric period, from 6.4% at Prince Rupert Harbour to 31.0% in the Strait of Georgia. The protohistoric period seemed to have much less variability.

Bone Infection and Tumours

Infection was evident in a number of long bones in all cultures. The frequency of this disease was 6.7% for the Early Cupisnique phase, 4.8 % for the Classic Cupisnique phase and 24% for the Salinar culture.

The only clear case of treponematosis was in one Salinar individual (interment XLV) who exhibited saber shins bilaterally. This was tentatively diagnosed as Yaws in Chapter 4. Treponematosis has a long history in the New World. Cybulski (1991) identified lesions suggestive of one of these infections from individuals on British Columbia's west coast dating to 1,500 B.C. Baker (1998) found evidence for treponematosis in the northeastern United States dating to pre-Columbian times and Hutchinson *et al.* (1998) for Georgia and Florida back to 400 B.C. Powell (1998) indicated an earlier date for these disorders in the American southeast, to 1,000 B.C. with lesions recognizable as the modern forms of these diseases from 1,000 A.D. Wilson (1998) found a similar pattern on the Texas gulf coast. Mansilla and Pijoan (1998) found evidence for treponematosis in Mexico in the prehispanic period. Powell and Wilson found evidence of changes in expression of treponematosis over time. Wilson (1998:234) suggested "clinal variation of the disease in response to host behavior and/or natural environment".

The jump in infection frequency during the Salinar culture could be explained in two ways. Wood *et al.* (1992) argued that populations with lower levels of infectious disease of bone may actually be less healthy than those showing a high frequency of this disorder since the latter were able to survive while the disease progressed. The second explanation deals with population density. Endemic diseases would be transmitted from individual to individual more readily as population density increased. Population density increase would result from limited fresh water resources consequent to the long term cycle of repeated El Niño events. Compounding this would be increased population density consequent to increased militarism. Both of these pressures acting in concert would put considerable pressure on fresh water resources and greatly increase population density and the possibility of pathogen transmission.

Importation of "new" diseases as a consequence of increased long distance trade could also lead to more evidence of infectious disease. Mims (1980: 231) in his discussion of sources of new infectious diseases included "domestication of animals, moving into new habitats, increased rate of movement, new patterns of sociosexual activity, increased survival of susceptible individuals". During the latter part of the Cupisnique cultural complex, diseases may have been transported with ideas, people, food, or other products from the highlands, the jungle or from other coastal regions. These diseases may be epidemic and leave no trace on bone, but may also be chronic leading to the types of changes evident in the Salinar population.

Cancer was evident at Puémape, something unreported by Ubelaker in his studies of populations in Ecuador (1980a, 1980b, 1983). Multiple myeloma was evident in an elderly woman from the Early Cupisnique phase.

Inflammatory Arthritis

Buikstra *et al.* (1990) described an adolescent from the Tiwanaku period Omo site in the south of Peru. The adolescent skeleton, dated between 950 and 1100 A.D., had joint lesions and growth retardation that they diagnosed as juvenile rheumatoid arthritis.

Ortner and Utermohle (1981) made the same diagnosis for the erosive arthritis evident in a woman from Kodiak Island, Alaska. Her remains predated European contact, dating prior to 1200 A.D. They described the difficulties in diagnosing an arthritis without clinical symptoms and the different appearance of radiographs of clinical cases versus bare bones. Another difficulty, also present in this study, was that the skeletal remains were often incomplete, or as part of a multiple interment so that comparison of left and right sides was not possible. This prevents the consideration of symmetry. It also removes the possibility of determining differences in prevalence by sex or age.

Merbs (1983) described lesions in the metacarpals of two males from the Sadlermiut skeletal series. These Inuit people became extinct in 1902-1903 and the skeletal series he studied dated within the past 500 years. He diagnosed the observed joint destruction as rheumatoid arthritis. Cold injury was offered as a differential diagnosis. He indicated that other individuals (number unspecified) showed milder lesions. The lesions he described destroyed the joint surface, unlike the erosions in this study which were periarticular.

Rodnan *et al.* (1983) indicated that there may be genetic relationships with a number of arthritides. HLA-B27 has been linked to arthritides such as psoriatic arthritis (20% association), juvenile chronic arthritis (20% association), arthritis associated with intestinal arthropathy (5% association) but the association increases to 50% when there is sacroiliitis. Reiter's syndrome and ankylosing spondylitis are HLA-B27 positive in 90% of cases. Cavalli-Sforza *et al.* (1990) indicated that the gene frequency for HLA-B27 is from 0 to 2% in this region of the world. This raises the possibility that the populations at Puémape had a locally higher frequency of this gene. Such a situation would be analogous to that of the Athabascan Navajo Indians of the American southwest and the Haida Indians of the Queen Charlotte Islands of Canada's west coast who have a locally high frequency of this HLA antigen and high rates of spondylitis.

Arriaza (1993) noted that the frequency of ankylosing spondylitis is 11% for the Navajo. Morse *et al.* (1980) reported a 36% frequency of HLA-B27 in the Navajo. Haida have a 20% frequency of this disorder (Sievers and Fisher, 1981) and a 50% frequency of the HLA-B27 gene. Other populations with a high frequency of this gene are the Alaskan Inupiat with a 25% frequency (Boyer, Lanier and Templin, 1988) and Bella Coola Native Americans with a frequency of 25% (Khan, 1987). Why these locally high gene frequencies arose is not clear although Arriaza (1993) suggested the possibility of the founder effect.

There was evidence of at least two inflammatory arthritides at Puémape and at least one of these was a spondyloarthropathy. The next section of this chapter will consider their differentiating features and the reasoning that led to the diagnosis of the disorders at Puémape. The spondyloarthropathies have in common several features. These include an association "with HLA-B27, absence of rheumatoid factor in the serum and lack of rheumatoid nodules" (Rodnan and Schumacher, 1983:85). The classic inflammatory component is enthesopathy (Rodnan and Schumacher, 1983). Axial joint involvement is classic for these disorders, the sacroiliac joints and thoracolumbar spine the most common areas of involvement (Rodnan and Schumacher, 1983; Masi and Medsger, 1989).

The differential diagnosis for the individual from the Salinar culture (Figures 4.11 and 4.12) came from the following considerations. The spinal enthesopathy and peripheral joint enthesopathy are suggestive of one of the spondyloarthropathies. Four differential diagnoses are possible. These are ankylosing spondylitis, Reiter's syndrome, psoriatic arthritis and arthritis associated with chronic inflammatory bowel disease. The pattern of upper and lower limb involvement also varies for these disorders.

Reiter's syndrome and psoriatic arthritis were ruled out since the syndesmophytes in these disorders are nonmarginal and coarse. Unlike those in anylosing spondylitis, these syndesmophytes are not continuous. Arthritis associated with chronic bowel disease has features indistinguishable from ankylosing spondylitis, but is not commonly associated with osteoporosis and is less common, at least in modern day populations (Rodnan and Schumacher, 1983). The spondyloarthropathies are constant in involving the sacroiliac joints, however the interment showing these spinal lesions does not have a pelvis. Ankylosing spondylitis always affects the sacroiliac joints bilaterally, the others generally unilaterally.

Also evident at Puémape was diarthroidial joint inflammation and erosions affecting the upper and lower extremities (Figures 4.3, 4.4 and 4.5). This was diagnosed by the following reasoning. This disorder was only found in adults, with a sex ratio of 11:7 males to females. The ratio of erosive changes involving tarsal, metatarsal and foot proximal phalanges compared to carpal, metacarpal and hand proximal phalanges was 6:5 in the Early Cupisnique population, 1:0 in the Classic Cupisnique population and 12:13 in the Salinar population. Overall this is an essentially equal representation of the disorder in the upper and lower limbs. This would tend to rule out Reiter's syndrome which has a predilection for the lower limbs (Chapman and Nakielny, 1984). Arriaza (1993) noted that both Reiter's Syndrome and psoriatic arthritis are uncommon conditions. This leaves ankylosing spondylitis or intestinal arthropathy as associated with Crohn's disease and ulcerative colitis (Rodnan and Schumacher, 1983) as the other differential diagnoses aside from rheumatoid arthritis. Ankylosing spondylitis, however, rarely affects the small joints of the hands and feet (Greenfield, 1980).

Psoriatic arthritis has as its primary form an asymmetrical distal interphalangeal arthritis (Greenfield, 1980). A second form generally involves the sacroiliac joints with more severe interphalangeal joint changes (arthritis mutilans). The third form is indistinguishable in pattern to rheumatoid arthritis, however it is negative for rheumatoid factor (Rodnan and Schumacher, 1983). A difficulty with a diagnosis of psoriatic arthritis is that it falls in direct opposition to the observations of Boyer *et al.* (1988) and Gofton *et al.* (1972). They noted a very low incidence of psoriasis in North and South American native peoples. It seems unlikely then that if psoriasis and psoriatic arthritis are rare elsewhere in the New World that they would be common on the North Coast of Peru.

Although uncommon in the general population, Reiter's Syndrome may be common locally or sporadically due to the presence of bacteria known to be involved in the pathogenesis of this disorder. Morse *et al.* (1980) noted the high incidence of Reiter's Syndrome in the Navajo, argued to be a consequence of endemic shigellosis and high levels of HLA-B27. Inman *et al.* (1988) reviewed the onset of symptoms of Reiter's Syndrome in a population after an outbreak of salmonellosis. These people had otherwise been healthy until the gastrointestinal illness. Masi and Medsger (1989) indicated that at least six species of bacteria have been implicated. These are Shigella, Campylobacter, Salmonella, Klebsiella, Yersinia and bacteria associated with sexually transmitted diseases (*eg.* Chlamydia, Mycoplasma and Neisseria species).

Notably absent at Puémape were erosions and fusion of the sacroiliac joints, features suggestive of rheumatoid arthritis (Greenfield, 1980). Another possibility, however, was that the erosions visible in these populations represented early disease before the sacroiliac joints became involved. None of the erosions of the bones of the hand or foot were visible on radiographs as Dr. Elera Nuñez did not comment on them and I did not find them when I specifically looked for them. This is not an unusual situation. Rothschild and Woods (1991) noted that these small erosions do not appear on X-rays.

Calcaneal enthesopathy and the inflammatory arthritis was present in interments XL, LXIX, XXXVI. The bilateral presence of this enthesopathy is suggestive of one of the spondyloarthropathies but is not specific to any one of them. However, because this condition is associated with the small joint inflammatory arthritis in these populations, there is support for a spondyloarthropathy over rheumatoid arthritis (Rodnan and Schumacher, 1983). Individuals with the erosive arthritis without the calcaneal enthesopathy may represent the same disorder, or another condition entirely. The former is more likely. There was no other evidence of enthesopathy in these populations aside from individuals with short flexor enthesopathy as described by Rothschild and Woods (1991). Alternatively, these enthesopathies may be robust short flexor insertions in keeping with the overall robusticity of these people.

Another possible diagnosis, rheumatoid arthritis, is also difficult to make since symmetry of lesions is difficult to prove or disprove in this population. The sex ratio is not suggestive of this disorder. Rheumatoid arthritis does not involve the spine except for the upper cervical spine, particularly the atlas and axis. Interment LXXXVII, an adult of unknown sex from the Early Cupisnique phase had an erosion of the dens (Figure 4.3) which supports a diagnosis of rheumatoid arthritis. Greenfield (1980) noted that the posterior base of the dens is a particularly common site of erosions. Sacroiliac joints are not involved (Greenfield, 1980). Joints primarily involved are the metacarpal-phalangeal joints, metatarsal-phalangeal joints, proximal interphalangeal joints and carpal joints. The knee is commonly involved, however, Greenfield (1980) noted that erosions at the knee are rare. At Puémape there was no bony reaction to the erosions which is also in keeping with rheumatoid arthritis (Rothschild and Woods, 1991; Rothschild, Woods, and Ortel, 1990; Rothschild, *et al.* 1988). Using the classification in Rogers *et al.* (1987: 181) this erosive arthritis does indeed fulfill the criteria for rheumatoid arthritis.

Rothschild *et al.* (1988) reported the presence of rheumatoid arthritis in North America during the Archaic period (3,000 to 5,000 B.P.) in what is now the southeastern United States. The pattern of lesions and the appearance of the lesions in the population at Puémape are the same as those described by Rothschild *et al.* (1988). The most marked difference is the lack of significant osteoporosis in the individuals at Puémape. Rothschild *et al.* (1988) noted that osteoporosis may be variable in patients with spondyloarthropathy or rheumatoid arthritis, but eventually develops in all people with rheumatoid arthritis. The inflammatory arthritis found in the populations at Puémape is not associated with local osteoporosis nor reactive bony sclerosis. Since there does not appear to be any bony reaction, it is possible that the individuals at Puémape had the disorder in an early phase.

The inflammatory arthritis evident at Puémape is likely to represent several conditions. The diagnoses of ankylosing spondylitis and rheumatoid arthritis seem assured. However, the high frequency of erosive joint changes, 53% in the Early Cupisnique population, 10% in the Classic Cupisnique population and 65% in the Salinar population suggest that at least one other inflammatory arthritis is present. For the reasons outlined above, Reiter's syndrome is the most likely candidate.

There is also the possibility that an inflammatory arthropathy existed at Puémape that is not present in present day populations. This seems unlikely given the range of instigating factors for erosive arthropathies today (reviewed in Rodnan and Schumacher, 1983). It seems unlikely that other causative agents would have disappeared over time. Also, Rothschild, Woods and Ortel (1990) indicated that it is very rare that another arthropathy co-occurs with rheumatoid arthritis. Therefore, it also seems unlikely that any one individual had more than one disorder.

Osteoarthrosis

Unfortunately many of the skeletons were so incomplete that side to side comparisons were not possible. However, there were osteoarthritic changes in a range of axial and appendicular joints. Of interest was the frequency of osteoarthrosis of the costovertebral joints. This disorder occurred evenly in males and females in the Cupisnique populations but found predominantly in males in the Salinar period (1:6 female to male ratio).

Costovertebral arthrosis, evident at Puémape, is not a common reported pathology. It was noted by Cybulski (1992) in a Tsimshian population disinterred from a burial ground at Greenville, B.C. These individuals were interred between

500 and 1300 A.D. Nine of 57 individuals were noted to have costovertebral arthrosis. One individual from Greenville had arthrosis of a first rib costovertebral joint. Eight others had a pattern similar to that found at Puémape in which the involvement was of the lower ribs. Of these the male to female ratio was 2:6. The disorder was found in all adult age classes.

Kennedy (1989) in his review of the stress factors posited to elicit particular patterns of osteoarthrosis noted that Merbs (1983) suggested that these lesions were subsequent to rib elevation consequent to carrying heavy loads on the back. This is possible since Cupisnique pottery shows humans carrying loads with tump lines (Carlos Elera, personal communication). Kennedy found no other suggested correlate for this pattern of osteoarthrosis.

As with all forms of osteoarthrosis, the one factor important to its development is severe stress or damage to the joint (Jurmain, 1977). He also points out that other factors "such as age, sex and hormonal influence must not be ignored" (Jurmain, 1977: 353). In a later paper (1991) he considered the joint surface changes being related to activity while joint margin changes were more directly related to age. Since costovertebral and zygapophyseal joint osteoarthrosis were common at Puémape it seems clear that these joints were under considerable stress during life. Carrying a load over uneven ground may be the causative factor for the development of costovertebral osteoarthrosis. It is curious that this is not a common condition cross-culturally considering that carrying of loads on the back is not unusual. Perhaps genetic or other predisposing factors were involved.

The frequency of the cuneiform-metatarsal defect was within the range noted for other populations however, the frequency among Cupisnique people was lower than that observed for other New World populations (26% for California native peoples and 13.1% for Aleuts and their predecessors, Tenney, 1991).

A defect in the base of the hallux first phalange was evident in adolescents (IX) and young adults (XLIII, XI, CXIII). Interment CXIII was from the Early Cupisnique population and the others were from the Salinar population. Interment XI had the defect bilaterally. This defect has the appearance of an erosion in the middle of the articular surface of the base of the first phalange. There did not appear to be a corresponding defect in the head of the first metatarsal nor were there any changes to the periphery of the involved joints. It varied in extent from 1/8 of the joint surface (interment IX) to 1/3 of the joint surface (interments XLIII and CXII). The differential diagnosis for this condition would be osteoarthrosis or a developmental defect. According to Greenfield (1972) this is the location for the most common form of osteoarthrosis of the foot. There was no associated evidence of trauma, infection or tumour.

Clearly, the pattern of osteoarthrosis changed during the Initial Period at this site. Throughout the Early and Classic Cupisnique habitation of Puémape, the spine and elbow were commonly affected. The patello-femoral joint also showed involvement during the Early Cupisnique phase, but not during the Classic Cupisnique phase. It was at this time that involvement of the feet became significant. During the Early Horizon Salinar culture the pattern became feet and hands (primarily feet) and spine (including costo-vertebral joints). The elbow, at least for Salinar people in this sample from Puémape, was much less stressed. Subsistence and social behaviours changed during the course of these cultures (see Chapter 3) and the pattern of joint osteoarthrosis reveals some of the effects of this change.

Bridges (1992), in her review of arthritis amongst North American native peoples observed that the frequency of osteoarthrosis of the major appendicular joints tended to occur (in descending order) in the knee, elbow, shoulder and hip. This matches the populations from Puémape in which shoulder and hip osteoarthrosis was uncommon. Although sample sizes from Puémape were small, knee osteoarthrosis was also less common than that involving the elbow.

Bridges (1992) also reported that osteoarthrosis in the foot was less common than involvement of the hand. The opposite was observed at Puémape. These results confirm her observation that the occurrence of osteoarthrosis within native American populations showed considerable variation. A functional interpretation of this pattern of foot arthritis could be walking over uneven ground carrying a load on the back.

Because of the small sample size for each population, it is not possible to identify whether males or females suffered more osteoarthrosis. Sex differences in the pattern of joint involvement similarly cannot be clearly stated. However, it appears that osteoarthrosis of the elbow was primarily a male affliction during the time of the Cupisnique cultural complex and Salinar culture.

Trauma

The frequency of fractures was fairly constant throughout the Cupisnique cultural complex but increased dramatically during the Salinar cultural period. The major increase in fractures during the Salinar cultural period suggests behavioral change. The archaeological interpretation was that the Salinar was a more militant society (Burger, 1992). As previously noted in Chapter 4, two of the fractures, the parry fracture and the zygomatic process fracture may well have been the result of violent acts.

Table 5.1 indicates the frequency of fractures in the three populations. The distinction in fracture types follows from the different forces leading to each type. The compression fractures primarily involve the spine and are the result of very large forces acting in compression. The other fractures are the expected variety of fractures resulting from falls (upper limbs), poor footing (lower limbs) and interpersonal violence. Three of the four individuals with the compressive fractures also had other fractures. As a group these individuals had the greatest number of fractures per person (2.5) versus 1.4 fractures per person without the compressive injuries.

Given the archaeological belief that there were greater amounts of long distance trade during the Salinar period (Burger, 1992) the compressive injuries may represent falls from a height with a load on the back. Alternatively, this may represent being thrown off a height after being taken captive in battle.

Figure 5.1 - Fracture Frequency at Puémape

Culture	Fractures*	Compression Fractures*
Early Cupisnique	6.7 %	0 %
Classic Cupisnique	4.8 %	0 %
Salinar	20 %	16 %

* = defined in text.

Since all fractures were healed, the individuals who had fractures lived for at least several months after the traumatic event.

Dental Attrition and Pathology

Clearly there was less variation in anterior dental wear than molar wear over time (Table 4.6). One additional feature noted on three individuals were facets on the lingual surface of incisors and canines. They were interment CXIII, a male from the Early Cupisnique population, interment CIX, a female from the Classic Cupisnique population and interment LXIX, a male from the Salinar population. These individuals represent 50% of those with molar dental wear of Scott 9 or 10 from all three populations. Although the etiology of these facets is unclear they may represent anterior dental wear consequent to use of these teeth to grind food as a consequence of the advanced wear of molar teeth.

These facets might then correlate with those described by Hinton (1981) in North American native peoples from the Libben site as well as the American southwest. He correlated these facets to antemortem loss of molars and the need to use the anterior teeth to grind foodstuffs. His study also found that the hunter-gatherer populations he studied tended to have greater anterior than posterior tooth wear. The Cupisnique and Salinar populations had ratios of anterior to posterior tooth wear similar to those of his agricultural populations, a not unexpected finding. Alternatively, these facets may represent the consequences of anterior tooth use for some activity not related to chewing.

Comparison with Populations from the Northwest Coast of North America

In reviewing research conducted on coastal populations in British Columbia, Cybulski (1990) noted a low frequency of dental caries (0.34%). This was argued to be the result of a low reliance on plant based foods. The higher caries frequency at Puémape would relate to a greater use of plants. The frequency of dental abscesses due to dental attrition was 50% in the prehistoric

Northwest Coast cultures. This is higher than at Puémape despite the greater dental attrition evident in populations from this site. The greater attrition at Puémape can be attributed to higher levels of shellfish and attendant sand in the diet, as the archaeological evidence suggests was the case. Trauma at Puémape during the time of the Cupisnique cultural complex was less than any of the Northwest Coast populations. During the Salinar habitation at Puémape trauma was comparable to frequencies at the sites of Prince Rupert and Namu. Straits of Georgia sites were intermediate. The high rates of trauma at Prince Rupert and Namu are attributed to warfare as it has been for Salinar populations.

Cybulski (1991) described skeletons found on Vancouver Island and dating from the Marpole cultural phase, that had skeletal changes suggestive of treponematosis. He diagnosed syphilis as the cause of these lesions. The pattern of bony expansion was similar to that in skeletons from Puémape. The Puémape skeletons, however do not have the same degree of bony expansion and the expansion does not usually involve the entire bone shaft.

For the Central Nootka site of Hesquiat, Cybulski (1978) observed low frequencies of trauma, less than that at Puémape. This population dated from the early 1900's. Cribra orbitalia was present at lower frequencies than at Puémape. There was evidence of osteomyelitis, as at Puémape, however the pattern was different. At Hesquiat there was involvement of the bones of the hands and feet. This pattern is suggestive of Yaws (Holmes and Perine, 1983; Rothschild and Rothschild, 1995), although Yaws is not believed to occur this far north of the equator (Holmes and Perine, 1983). Osteomyelitis was evident at lower frequencies than observed in remains from Puémape. Dental caries and attrition were less than at Puémape. Degenerative joint disease had a different pattern in this population as well. At Hesquiat the shoulder, elbow, wrist, hip, knee and ankle were the most involved, in this order of occurrence. The pattern for the Cupisnique populations was spine, elbow, patella, phalanges of feet and costovertebral joints. The Salinar pattern was spine, phalanges of feet, costovertebral joints and proximal radius and metacarpals. Although the Hesquiat and the Cupisnique populations exploited marine resources, it is clear that their means of doing so was significantly different since there was a different pattern of joint stress revealed by the pattern of osteoarthrosis. The Salinar culture could be expected to be distinct based upon a more terrestrial subsistence pattern that included intensive agriculture.

Greenville was a Nisga'a site on the far north coast of the B.C. mainland (Cybulski, 1992). This burial ground was used between 600 and 1300 A.D. Dental caries were negligible and dental attrition was less than at Puémape. The reasons for this have been previously considered and relate to the differing amount of plant material and sand in their diets. Six of seven children and one infant had cribra orbitalia as well as two young adult females and one elderly female. The reasons for this would have been similar to that for the Cupisnique populations. Trauma was at a higher frequency than during the Cupisnique cultural complex and comparable to the Salinar population. The pattern of trauma was suggested to represent interpersonal violence such as warfare. The five most common areas of osteoarthritic joint changes were spine, sacroiliac joints, shoulder, elbow and atlanto-occipital. This differs from populations at Puémape, suggesting subsistence and cultural activities stressing the skeleton and joints in differing patterns. It is notable that the Greenville population had a different pattern of osteoarthrosis than the Hesquiat population despite a similar subsistence base.

Comparison with Populations from Ecuador

Ubelaker (1980a) reported the results of his osteological analysis of human remains from a preceramic site on the coast of Ecuador. This population lived on the Sta. Elena peninsula and dated to approximately 6,000 B.C. (Ubelaker, 1980a). Trauma was observed at low frequency, as at Puémape, however the majority of fractures were of the upper limbs. This was related to fending off blows directed to the head or body. Lower limb bone injuries were at lower frequencies than at Puémape. Prevalence of bone infection was lower than at Puémape. Alveolar abscesses were also at lower frequency than at Puémape. Dental hypoplasia was evident at lower levels than at Puémape. There was no evidence of porotic hyperostosis at Sta. Elena. Average age at death was similar to that for the Early Cupisnique phase (38 years). At Sta. Elena the female life span averaged 38 years and males averaged 34 years.

Ubelaker (1980b) described skeletal remains from the highland Cotocollao site of Ecuador. These remains dated between 1100 and 540 B.C. and were therefore coeval with the Early and Classic Cupisnique populations at Puémape. He found changes in bone representing osteomyelitis in only one of 42 males and four of 40 females. This frequency is lower than at Puémape for the same time period. Trauma was only found in four of 199 individuals a rate much lower than at Puémape. However, two of the individuals had cranial trauma. The other fractures were those of the leg and foot, a pattern also found in the Cupisnique population. Dental hypoplasia was present in only three individuals, a rate comparable to that at Puémape. There was no evidence of porotic hyperostosis at Cotocollao. Average age at death for this population (35 years for males and 34 years for females) was slightly less than that of the Early Cupisnique population (38 years), but comparable to the Classic Cupisnique population (36 years).

In another study, Ubelaker (1983) described skeletal remains of individuals of the Guangala culture, a coastal Ecuadorian population that was coeval with the Salinar culture. He noted facets on metatarsals related to habitual squatting posture in one female and two males. These facets were also found in males from the Salinar culture. Evidence of traumatic episodes appeared less frequently than in the Salinar culture and matched that from the Cupisnique cultural complex. There was none of the compression fractures commonly found in the Salinar population. The frequency of infectious disease was less in the Guangala culture. Of the four infants and children, in his skeletal series that survived birth in the Guangala culture three had porotic hyperostosis. Two of these were infants. No adults showed evidence of this condition, unlike the Salinar pattern. The frequency of alveolar abscesses was less than found in the Salinar population, while dental hypoplasia was equally rare (one individual in each population). Average age at death was 39 years, higher than that of the Salinar culture (31 years).

The populations in Ecuador appeared to be healthier during comparable time intervals than the populations at Puémape. In particular, porotic hyperostosis, alveolar abscesses, infection and trauma were all at equal or lower frequencies than at Puémape. This suggests less parasitic and infectious disease and less dental attrition.

Chapter 6 - **Conclusions**

Answers to the questions posed in Chapter 1 are as follows:

1. The infant and child populations from all three cultures demonstrated slower growth than the reference populations of Gindhart (1973) and Scheuer *et al.* (1980). As predicted, the growth of infants and children at Puémape did match that of a native North American population (Ubelaker, 1989) suggesting that a lower growth rate is the norm in these populations. Furthermore, this suggests that Amerindians, in general, have lower growth rates than recent populations of European descent.
2. Harris lines were present, however, whether they were associated with growth rate or metabolic disturbances during childhood and adolescence was not discernible. There was evidence suggesting that care must be taken to minimize both intra- and inter-observer error as observed by Grolleau-Raoux *et al.* (1997) and Macchiarelli *et al.* (1994).
3. Porotic hyperostosis was present suggesting that although dietary sources of iron were adequate, iron deficiency anemia was common. Overall, the pattern at Puémape corresponded to that described by Ubelaker (1990) and Kent (1980). They observed that sedentism with high population density and a high level of infectious disease was positively correlated with this disorder.
4. Comparison with other New World coastal populations allowed another measure for the success of adaptation at Puémape. As previously discussed

in Chapter 5, there were significant differences between coexisting populations from Ecuador and Puémape. When followed over time, however, there were similar trends in Ecuador and at Puémape. For example, life expectancy at Puémape was not markedly different from the pre-existing and coexisting populations in Ecuador. In both regions life expectancy decreased with time. Furthermore, the frequency of some forms of pathology increased over time. These included porotic hyperostosis, trauma, infectious disease and dental disease. Therefore, on a population level, the overall decreasing trend in health at Puémape was similar to that in Ecuador.

5. Patterns of osteoarthrosis varied among the three cultures at Puémape. There were also at least two forms of inflammatory arthritis at Puémape. One of these was ankylosing spondylitis. The second was rheumatoid arthritis. There was also the possibility of a third erosive arthropathy. The frequency of these inflammatory arthritides also varied between cultures. The inflammatory arthritic diseases were not evident in Ecuador. The pattern of osteoarthrosis in populations from Ecuador also showed variation from that observed at Puémape (Ubelaker 1980a; 1980b, 1983).
6. None of the pathology evident in skeletons from Puémape appears to represent a disorder unknown to modern medicine.
7. Dental pathology did vary among the three cultural phases. As postulated, the Salinar population had the lowest rate of molar attrition. Caries were much more frequent in the Salinar population. These two features support the archaeological interpretation of subsistence.

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Appendix I - Raw Data

Bone Length Data for Infant and Child Interments at Puémape

Interment	Femur Length	Tibia Length	Humerus Length	Radius Length	Ulna Length
	L / R	L / R	L / R	L / R	L / R
XVI	NA/143	NA	110/111	NA/93	NA/96
XXVII	73/73	62/62	62/62	51/51	54/54
XXIX	NA	NA	NA	NA/60	NA
XXX	NA	NA	69/NA	NA/55	NA/63
XLVI	89/88	74/74	NA	56/56	64/NA
LVI	55/54	49/49	50/50	42/42	42/43
LVII	NA	NA	74.5/74.5	NA/61	70.5/70.5
LXIII	NA/78	71/69	68/68	67/67	65/66
LXXXI	125/127	104/105	98/98	81/81	88/88
XCVI	NA/75	NA	NA	48/48	63/NA
CI	NA/100	84/84	NA	62/NA	70/NA
CII	75/NA	NA/62	62/NA	NA	59/NA
CXI *	76 X 2/ NA	65 X 2/ 56	NA	52 X 2/ NA	NA
U	NA	NA	NA/80	NA	NA

All measurements in millimeters.

* Commingled remains of three infants

Harris Lines in the Skeletal Population from Puémape

Interment	Cultural Affinity	Sex, Age	Location (interpreter)
II	Unknown	U, C	Femora (E)
IV, V	Salinar	U, I	femur (E)
VI, VII	Salinar	M, YA	tibiae (E)
VIII	Salinar	F, YA	femur, tibiae (E)
X	Salinar	M, MA	femora, humeri (E)
XI	Salinar	F, YA	femora (E)
XII	Salinar	U, C	7 in proximal tibia, distal femur (RMG) 11 in femora, tibiae (E)
XIV	Salinar	U, C	1 (RMG)
XV	Salinar	U, U	femora, tibiae, fibulae (E)
XXI	Classic Cupisnique	F, YA	femora, tibiae (E)
XXV	Classic Cupisnique	F, OA	femora, tibiae (E)
XXXIII	Early Cupisnique	M, YA	humeri (E)
XXXIX	Salinar	M, YA	4 in distal femur (RMG) femora, humeri (E)
XL	Salinar	M, YA	femora (E)
L	Salinar	F, OA	femora (E)
LVIII	Classic Cupisnique	F, YA	femora, tibiae (E)
LXVIII	Salinar	M, Y-MA	femora, tibiae (E)
LXIX	Salinar	M, MA	femora, tibiae (E)
LXX	Salinar	U, C	femora, tibiae (E)
LXXI	Salinar	(M), YA	femora, tibiae (E)
LXXVI	Salinar	M, MA	femora (E)
LXXXVIII	Classic Cupisnique	U, U	11 in femora (E)
XC	Classic Cupisnique	U, C	8 in distal femur, tibia (RMG) distal femur, tibiae (E)
XCVI	Classic Cupisnique	U, I	1 in distal femur, tibia (RMG)
XCIX	Classic Cupisnique	U, C	8 in distal femur, tibia (RMG) femur, tibia(E)
C	Classic Cupisnique	YA	femora, tibiae (E)

Interpreters are Dr. Elera (E) and Milan Gillespie (RMG)

F = Female; M = Male; U = Unknown; () = tentative assignment
I = Infant; C = Child; YA = Young Adult; MA = Middle Aged Adult; OA = Old Adult

Inflammatory Arthritis

Inflammatory Arthritis in the Early Cupisnique Population

Interment	Sex	Location
XXXII	F	metatarsals
XXXV	F	talus
XXXVI	F	carpals
XLIV	M	hand proximal* phalanges, proximal humerus
LXXXVII	U	dens, foot proximal phalanges
LXXXIX	M	hand proximal phalanges, foot proximal phalange, cuneiform
XCII	M	carpals, hand proximal phalanges
CXIII	M	foot proximal phalanges

Inflammatory Arthritis in the Classic Cupisnique Population

Interment	Sex	Location
LXII	U	metatarsals

Inflammatory Arthritis in the Salinar Population

Interment	Sex	Location
IV, etc.	U	metacarpal
VII	(M)	foot proximal phalanges
VIII	F	proximal phalanges
X	M	tarsals, metacarpals, carpals, hand proximal phalanges
XI	F	carpal, foot proximal phalange, proximal humerus
XIII	F	carpal, hand proximal phalange
XV	U	hand proximal phalange
XXXVIII	M	foot proximal phalange
XXXIX	M	carpal, hand proximal phalanges, metatarsals, foot proximal phalanges
XL	M	hand proximal phalanges, metatarsal, foot proximal phalange
XLI	(F)	foot proximal phalange, hand proximal phalange, metatarsal
L	F	metacarpals, hand proximal phalanges
LXVIII	M	metatarsal
LXIX	M	proximal phalanges
LXXIV	M	foot proximal phalange

* = proximal phalange refers to either the first or second phalanges, but not the terminal phalange of a digit

M = Male; F = Female; U = unknown; () = indicates tentative designation

Osteoarthrosis

Osteoarthrosis in the Early Cupisnique Population

Interment	Sex	Site of Osteoarthrosis
XXXII	Female	zygapophyseal joints
XXXIII	Male	cuneiform-navicular joint
XXXVI	Female	pedal phalange, zygapophyseal joints, lumbar discopathy, left distal femur, left patella
XLIV	Male	right humeral head, right patella, zygapophyseal joints, thoracic and lumbar discopathy
LXXXIII	Female	costotransverse articulations
LXXXVII	Unknown	carpals, cervical discopathy, thoracic discopathy, zygapophyseal joints
LXXXVIII	Female	cervical discopathy, thoracic discopathy, zygapophyseal joints
LXXXIX	Male	lumbar discopathy, zygapophyseal joints, radius, humerus, carpal
XCII	Male	thoracic discopathy, lumbar discopathy, costotransverse articulations, costotvertebral articulations, left radius, bilateral ulnae, bilateral glenoid fossae, bilateral humeri, bilateral patellae, left femur
CX	Female	lumbar discopathy
CXIII	Male	costotvertebral articulations, lumbar discopathy, zygapophyseal joints, base of first phalange of hallux

Osteoarthrosis in the Classic Cupisnique Population

Interment	Sex	Site of Osteoarthrosis
I	Female	left metatarsal, zygapophyseal joints, cervical discopathy, lumbar discopathy
XXV	Female	left talo-calcaneus, lumbar discopathy, zygapophyseal joints
LX	(Female)	zygapophyseal joints
LXII	Unknown	phalange
LXXV	Female	right patella, lumbar discopathy
C	Female	lumbar spondylolysis, costotvertebral articulations
CI	Unknown	pedal phalange of adult
CIII	Unknown	costotvertebral, bilateral radii, bilateral ulnae, bilateral humeri
CVI	Male	lumbar discopathy, zygapophyseal joints
CIX	Female	phalange, thoracic discopathy
CXVII	Unknown	lumbar discopathy

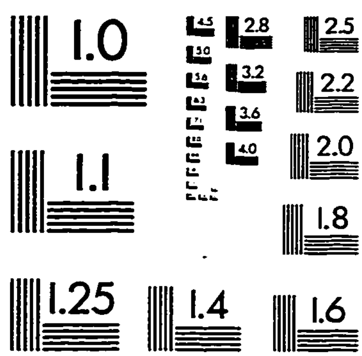
() = tentative assignment

Osteoarthrosis in the Salinar Population

Interment	Sex	Site of Osteoarthrosis
IV, etc.	Unknown	costovertebral, zygapophyseal joints, thoracic discopathy, lumbar discopathy
VII	(Male)	lumbar discopathy
IX	Male	base of first phalange of hallux
X	Male	cervical discopathy, thoracic discopathy, lumbar discopathy, spondylolysis L5, zygapophyseal joints, right glenoid fossa, metacarpal
XI	Female	right patella, cervical discopathy, zygapophyseal joints, base of first phalange of hallux bilaterally
XIII	Female	three phalanges, lumbar discopathy, zygapophyseal joints
XXXVIII	Male	zygapophyseal joints, carpal, phalange, left radius, left ulna, left glenoid fossa, costosternal articulations
XXXIX	Male	cervical discopathy, thoracic discopathy, lumbar discopathy
XL	Male	left radius, bilateral ulnae, left humerus, bilateral patellae, bilateral femora, pedal phalanges, left clavicle, cervical and lumbar discopathy, zygapophyseal joints, costovertebral articulation, pedal sesamoids
XLI	(Female)	thoracic and lumbar discopathy
XLIII	Male	pedal phalange, metacarpal, lumbar discopathy, zygapophyseal joints, costotransverse articulations, base of first phalange of hallux
XLV	(Female)	pedal phalanges, pedal sesamoids, cuboids, metatarsals, metacarpals, cervical discopathy, lumbar discopathy, left acetabulum, left femur, right humerus, right radius, right ulna
L	Female	carpals, metatarsal, metacarpals, tarsal, radius, cervical discopathy, zygapophyseal joints, costotvertebral articulations
LIII	Male	zygapophyseal joints, thoracic and lumbar discopathy, bilateral radii, pedal phalange
LXVI	Male	pedal phalange
LXVII	Male	lumbar discopathy
LXVIII	Male	lumbar discopathy, zygapophyseal joints, costotvertebral articulations

LXIX	Male	pedal phalange, carpal phalange, costovertebral articulations
LXXI	(Male)	lumbar discopathy, costovertebral articulations
LXXIV	Male	bilateral radii, metatarsals, pedal phalanges, carpal phalanges, bilateral femora, metacarpals, costovertebral and costotransverse articulations, cervical discopathy, thoracic discopathy, lumbar discopathy, zygapophyseal joints
LXXVI	Male	cervical discopathy, lumbar discopathy, zygapophyseal joints, costovertebral articulations

IMAGE EVALUATION TEST TARGET (QA-3)



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1653 East Main Street
Rochester, NY 14609 USA
Phone: 716/482-0300
Fax: 716/288-5989