Cribra Orbitalia in Highland Versus Lowland Populations of Peru

M.A. Thesis Proposal

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Abstract

The purpose of this study is to examine orbital lesions at the Phoebe Hurst Museum at University of California, Berkeley. The collection contains samples from both highland, lowland, and coastal groups, and spans a time frame of between BC 1100 to 1534 AD. True cribra orbitalia involves diploic expansion but in the past, any orbital lesion with porosity regardless of marrow hypertrophy was diagnosed as cribra. Many pathologies such as: rickets, scurvy, and inflammatory lesions can create porosity in the orbits. This has lead to the prevalence rates of cribra being unnaturally high, as Walker and coauthors (2009) noted, it is one of the most documented cases of pathology associated with archaeological sites. This research is important because the Peruvian collection at the Phoebe Hurst Museum has not been re-evaluated since new literature has challenged the manifestations of cribra. This sample of N=507 individuals includes skeletal remains from both highland (n = 58) and lowland Peru (n= 449). They will be examined visually and non-invasively using a system developed by Wilczak (2008).

My hypotheses are that: (1) cribra orbitalia will be more prevalent in juveniles than adults in both highland and lowland Peru, (2) that the coastal groups will have a higher prevalence of cribra orbitalia, and (3) that many of the cases of what was previously considered cribra orbitalia will be associated with other pathologies that can create porosity in the eye orbits and not true cribra (rickets, scurvy, etc.).

Introduction

The purpose of this study is to examine orbital lesions in the Peruvian collection at UC Berkeley, and differentiate between true cribrotic lesions, and other pathologies that can create porosity. Cribra was previously diagnosed when there was porosity located in the orbits, but true cribra involves marrow hypertrophy. Since many pathologies create porosity in the orbits, there has been an overestimated frequency of cribra in archaeological sites (Walker et al 2009). The Peruvian collection at the Phoebe Hurst museum at UC Berkeley has not been re-evaluated since the new classifications of orbital lesions have been created. The collection at the Phoebe Hurst museum contains specimens from both highland and lowland Peru excavated by Max Uhle starting in 1895 (Anton 1989, Menzel 1977). By comparing and contrasting the orbital lesions that are seen within the collection, it may be possible to create inferences

about dietary patters, and prevalence of disease between these two geographically separated regions of highland and lowland Peru.

Analysis of skeletal remains is an integral part of bioarchaeology, and paleopathology. The interpretations of the pathologies create views of the health and wellness of past populations. Buikstra and Ubelaker noted that, “Analysis of skeletal pathology can provide estimates of community health and this facilitate investigations of disease patterning in comparative perspective” (Buikstra and Ubelaker 1994:107). This research will view the pathology in Peru based on access to resources, diet, trade networks, and environmental conditions. Cribra orbitalia has been linked to a mixed marine and maize diet (Blom et al 2005), which is seen in coastal population of Peru, but not in the highlands where they have a terrestrial diet. Additionally, appropriate diagnosis of other orbital lesions will document health status differences. There are no documented studies of orbital lesions, or reassessment of the diagnosis of cribra orbitalia in the Peruvian collection of UC Berkeley as of this time.

Differential diagnosis is one of the focal points in paleopathology. Many diseases can create similar manifestations on bone which can be challenging to the scholars studying them when the disease signatures overlap (Marks and Hamilton 2007:217). In order to counteract the overlap between similar manifestations of disease, differential diagnosis must be undertaken. This type of diagnosis looks at all possible causes for the lesions, then views the complete set of skeletal remains looking for pathognomic (diagnostic features for a particular pathology), finally coming to a reasonable idea about which disease it is.

Another important concept in bioarchaeology is the osteological paradox. This concepts has three main points at its center, (1) demographic movement, (2) selective mortality, and (3) risk that accompanies hidden heterogeneity (Cohen et al 1994), yet only one is significant for this research, hidden heterogeneity (Wright and Yoder 2003). Each individual experiences health and wellness differently, and in order to properly interpret health, more information is needed about lesion formation. Proper differential diagnosis is important to understanding formation of lesions. This has led the the idea that lesions on adults could indicate that there was low frailty and survival that stems from a childhood disease. The risk of hidden heterogeneity in terms of frailty and health directly influence the hypotheses that I have created for this research.

The hypotheses that I will be testing are: (1) adults and juveniles/adolescents will have significantly different prevalence of cribrotic lesions, (2) coastal populations will have a higher frequency of orbital lesions than highland groups, and (3) that in many cases where porosity is seen in the orbit is not in fact a true cribrotic lesion but porosity from another pathology. Among the three major hypotheses that I have, I am also going to look at geographical patterning of the lesions, and see which regions have the highest frequencies of orbital lesions. In order to complete the research, I will be working at the Phoebe Hurst museum at the University of California Berkeley, for which I already received approval (which is attached). I will be collecting data on location, age, sex, and types of orbital lesions. After the data has been collected, it will be assessed for appropriate statistical tests. As of this proposal the tests will be chi-square, with some possibility of Fisher's exact or Yates continuity correction. Phi and Cramer's V will be used for the post hoc tests to view the strength of the relationship, and if possible

odds ratios will be calculated for males/females and highland/lowland using binary logistic regression.

Background

In the case of certain types of anemia, cribra orbitalia is classified by diploic expansion. As outlined by Walper et al., 2009 the trabeculae, spongy bone, grow at right angles to the orbital laminae. In the case of periostitis and osteitis, there is increased vascularity, and possible bone resorption. Vitamin C deficiency is associated with hemorrhagic processes and can also create porous bone in the eye orbit.

Most of the stable isotope research from Peru has come from Ancon. Slovak and Paytan (2009a) looked at dietary diversity during the Middle Horizon because previous research indicated a significant decrease in marine resource consumption (Slovak and Paytan 2009a). The close proximity to water gave individuals access to a varied diet that included other food such as lucuma, quinoa, mani, avocado, and beans (Menzel 1977). Other food such as maize (C4 plants), lama, and guinea pigs have been found in the archaeological record (Menzel 1977). Maize was probably brought in from the Chancay and Chillon Valleys because Ancon could not support the water needed for intensive corn cultivation (Menzel 1977).

Slovak and Paytan (2009a) looked at nitrogen, oxygen, and carbon stable isotopes. Carbon isotopes are helpful when looking at the bulk protein intake of an individual, Nitrogen isotopes look at marine versus terrestrial sources of food, and Oxygen isotopes are best used to look at weaning practices since it involves water (Slovak and Paytan 2009a). What was found during this study is that there was greater dietary diversity and higher consumption of marine resources in the Early Middle

Horizon than in the Late Middle Horizon (Slovak and Paytan 2009a). The carbon 13 ratios fell very close to the marine protein lines. The calcium carbonate and collagen values indicated that some people had easier access to maize while others did not. A bulk of the dietary energy came from C4 plants (maize) as well which is interesting given that C3 plants are found at the site. The nitrogen isotope results showed there was a greater decline in N15 over time and the variability of these values could have indicated that the people at Ancon were relying less on marine resources and more on C4 plants and terrestrial animals. Increased presence of caries, or abscesses, in populations have been correlated with an increasing dependency on corn, and many of the individuals looked at (27/32) were seen to have at least one carious lesion or more (Slovak and Paytan 2009a).

In the LMH, the carbon and nitrogen isotopic signatures were switched (Slovak and Paytan 2009a). During this time, the carbon 13 values increased, meaning that there was an increase in C4 plants consumption and a mixed diet or C4 plants and marine protein. Slovak, Paytan and Wiegand (2009b) examined strontium isotopes in another paper and noted that there was at least one individual who migrated from the Wari/Ayacucho areas and that could help to explain the interrelated trade network of maize (Slovak et al. 2009b).

Other researchers such as Blom and coauthors (2005) have looked at anemia and mortality rates of children along the coast of Peru. They used Hrdlicka's (1914) original diagnoses of porotic hyperostosis and noted that there was a high number of individuals diagnosed with the pathology along the coastal regions of Peru. Blom and coauthors (2005) looked at 1,465 individuals; 512 from the Peruvian collection at the

Field Museum of Natural History in Chicago and 953 from Moquegua, Peru. The goal of the research was to examine the pattern of lesions by region, and look at factors that would influence the prevalence of the disease.

Blom and coauthors found that 23.1% (n=402) of adults in the sample exhibited signs of cribra orbitalia (Blom 2005). In children, the prevalence was 81.8% (n=66). Blom et al. did find an associated between cribra orbitalia and porotic hyperostosis and postulate that both cribra and porotic hyperostosis are related pathologies in terms of their etiology. Part of this study was to look at heterogeneity in frailty of people in terms of the osteological paradox (Wright and Yoder 2003). The conclusion of the research was that children in the Central coast were less likely to survive with anemia than those children living in the South or South Central areas (Blom 2005), and the prevalence of the lesions also increased with time. Blom (2005) also found that a mostly maize or marine based diet was not associated with higher rates of cribra orbitalia, but that mixed diets (marine and maize) had higher frequencies of individuals with cribra orbitalia.

Ales Hrdlicka was one of the first people to examine pathologies in Peruvian skeletal materials. He explored many of the regions in my thesis sample including, Ancon, Pachacamac, Occujage, Chicama Valley, Chan Chan, and the Moche Valley. Hrdlicka noted while studying these skulls that people residing in the mountain regions showed no signs of symmetric osteoporosis (cribra orbitalia) (1914). Hrdlicka described this pathology as a condition that manifests during infancy and affects solely the cranium (Hrdlicka 1914). In extreme cases it was considered to look like, “a low growth of coral” (Hrdlicka 1913:58). He stated that this pathology was often fatal in the initial stages, indicating the possibility that children were more affected than adults. He also

noted porosity on the greater wing of the sphenoid as part of this symmetrical osteoporosis, but this lesions is now considered pathognomic for scurvy which also creates porosity within the eye orbits (Ortner 2003).

Methods

Sites represented	N	Time period	Location
Ancon	19	BC 1100–1476 AD	Coastal
Chancay	19	BC 450–1476 AD	Coastal
Pachacamac	14	400–1534 AD	Coastal
Supe	3	600–1100 AD	Coastal
Cuzco	25	1300–1500 AD	Highland
Chinca[2]	1	500–1534 AD	Coastal
Ancon	2	600–1534 AD	Coastal
Limatambo	2	No dates	Coastal
Chinca	18	1430–1580 AD	Coastal
Ica	11	550–1534 AD	Coastal
Marca Huamachuco	8	No dates	Highland
Lima	2	No dates	Coastal
Pisco	2	BC 500–1534 AD	Coastal
Chanchan	1	100–1534 AD	Coastal
Huaca	1	No dates	Coastal
Moche	1	100–1534 AD	Coastal
Tacala	1	No dates	Coastal

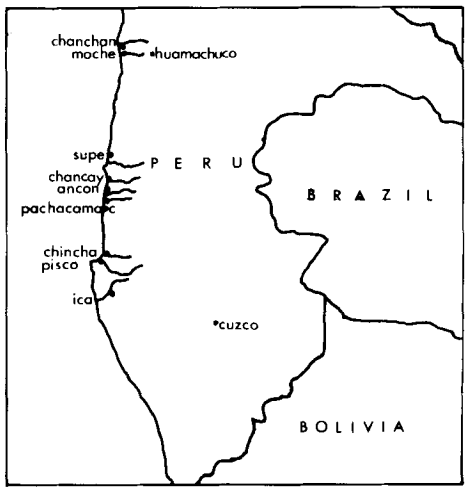

Figure and Map From Anton 1989

The samples for my thesis that I will be examining were excavated by Max Uhle and come from Marca Huamachuco (no dates), Cerro de Trujillo (no dates), the ruins of Moche (100-1534 AD), the ruins of Pachacama (400-1534 AD), Ocucaje (no dates), Tate-Culpaca, Valley of Chincha (500-1534 AD), Huaca de Alvarado (no dates), Pampa de Canelos, Pampa de Cotegros, Ancon (1100 BC-1476 AD), and Cuzco (1300-1500 AD). There are mostly coastal sites, but two, Cuzco, and Marca Huamachuco are highland sites.

A total of approximately 507 crania will be looked at (n= 58 for highland and n=449 for coastal), and the previous pathological designations will be compared to the new ones that are being assessed. In the past few years Wilczak (2008) has created

new designations for diagnosing orbital lesions based on the macroscopic examination of specific bone changes, and their etiology. Each of the 570 crania will be viewed, non-invasively, for the lesions and scores will be assessed for each specimen by the system created by Wilczak (2008). The scoring system is attached to this proposal and involves separating the eye orbit into anterior and posterior portions. Pore size, pore density, percent of orbit affected with porosity, diploic expansion, and vascular channels are all scored on a system from 0 to 4 with zero being no manifestation and 4 being the most pronounced. The scoring criteria for each orbital area accommodates multiple diagnoses that are scored on a system where 1 is the most severe lesion, and 3 is the least severe lesion. The anterior portion is where true cribrotic lesions manifest, and it has been shown that different lesions can occur both in the anterior portion and posterior portion. The anterior portion of the orbit can be scored for true cribra, coalesced pores, inflammatory lesions, and porosity with increased vascularity. The posterior orbits can be scored for curvilinear porosity, porosity without vascularity, and inflammatory lesions with both vascularization and porosity. Plaques can be seen in numerous locations within the eye orbit and will be scored for presence/absence and the size of the plaque. Lastly, hypoplastic defects on all left teeth will be scored for the number of LEH (linear enamel hypoplasias) which are an independent indicator of health to compare with the orbital lesions.

Expected Findings

Through this research, the expected findings are that children and adults will have significantly different prevalence rates of cribra orbitalia, and that coastal populations will have higher prevalence of cribra orbitalia as compared to the highland

populations. Walker and coauthors (2009) supported that childhood anemia would most likely be the cause for severe lesions because most active porotic lesions with no remodeling were found in juvenile and adolescent remains. Adults were found to have signs of remodeled lesions without the severity of the childhood lesions (Stuart-Macadam 1985; Walker 1985, 1986).

In terms of geographical patterning associated with cribra orbitalia, it has been shown that coastal populations are more likely to manifest orbital lesions than the highland groups. Walker et al. (2009) noted that parasites and chronic sickness can also cause anemia by depleting B12. It has been shown that pre-Columbian mountain populations in Peru showed no orbital lesions when they were examined in the early 1900's (Hrdlicka 1914, Blom et al 2005). Blom and coauthors found in the 2005 study that individuals were more likely to have childhood anemia in arid environments. They also were able to show that children buried in the lower altitudes, possible raised in lowland areas, who were closer to the coast, and had a diet heavy in marine resources were less likely to die from childhood anemia. Wilczak (personal communication) and others have noticed higher prevalence of inflammatory lesions in coastal populations, and this research may provide more evidence to support that theory.

One of the other expected findings of this study is the visual diagnosis of healing subperiosteal hematomas can create orbital lesions (Walker 2009). These lesions can be caused from numerous pathologies including, but not limited to, scurvy, traumatic injury, and rickets. During healing, the clot becomes a vascular plaque that can mimic the look of cribra orbitalia. These lesions are seen mostly in children because the periosteum attached to the orbital roof is not as strongly attached as in

adults, and is highly vascular in children. The scoring system by Wilczak (2008) will be useful in differentiating these lesions from true cribra orbitalia and other orbital lesions.

Schedule

Research will be conducted starting in May of 2011. A preliminary trip to UC Berkeley to discuss access to the collection was completed on February 17th, 2011. On that day the card catalogue was viewed for possible samples. Research will begin on May 31, 2011 at the Pheobe Hurst Museum. The visual research will be completed by August of 2011, and then taken back to SFSU where the statistics will be run and more background research will be completed. It is expected that the data analysis will last no more than three months, ending in November 2011.

Thesis writing will begin shortly after the data has been analyzed. This will involve quite a lot of in depth research that includes pathology, stable isotope studies, geography, climate, and other areas. In the Fall 2011 semester, Anth 899 will be taken as the literary review portion of the thesis. During this semester, the literary review will be assembled. Anth 897, Directed Thesis Advising and Support, will be taken in the Spring of 2012 to further the research and correct any problematic areas and address problems and limitations of the study. The culminating thesis experience, Anth 898, will be taken in the Fall of 2012 with hopes that it will be fully competed by the end of Fall 2012.

Committee

Primary - Dr Cynthia Wilczak
Secondary - Dr. Mark Griffin

Phoebe Hurst Museum Scoring System

Anterior/Corner and Posterior Porosity: Both are scored on Pore size, Density and Percent affected

Pore size:

0 = no porosity
1 = pinpoint
2 = pinpoint to 0.5 mm
3 = > 0.5 mm
4 = coalesced (also include if pore density low but at least 2 pores overlap)

Pore Density

0 = no porosity
1 = low < 15 / cm sq.
2 = moderate 15-25
3 = high 25-50 cm sq.
4 = coalesced, generally high density with at least ¼ of area showing coalescence to give cribriform appearance.

Porosity % affected
0 = none
1 = ¼
2 = ¼-1/2
3 = > ½

Diploic expansion (The porous area is raised or “puffed out)

0 = none
1 = slight, barely discernible
2 = clearly present
3 = severe exceeds 1 mm in height

Vascular Channels

0 = none
1 = barely discernible to slight
2 = mild, clear channels but on less than 1/3
3 = moderate, clear channels on 1/3 -1/2
4 = severe, clear channels on greater than ½

Plaque = well-defined surface deposit of smooth bone
0 or blank = no plaques present
Record # of discrete plaques if present

Plaque size = maximum diameter of bone plaques
0 or blank = no plaques present
Record size of each plaque in mm, separated by commas.

Diagnosis

CO active = Coalesced, plus Diploic expansion on anterior including ant/lat corner
CO? = Coalesced on anterior orbit including anteriolateral corner
AP = Anterior affected by porosity (not coalesced) can have slight vascular impressions
PP = Porosity on posterior, no vascular channels.
IF = inflammatory lesion with diffuse porosity and vascular channels across posterior, may also partially affect anterior but if extensive use **IFANT**
APIF = porosity and vasc channels with no coalesced pores in ant lat corner
CV= curvilinear posterior with possible anterior affected with porosity and/or vascular channels. Mostly limited to posterior, if significant extension onto anterior surface, code with **APIF**.

Hypoplastic Defects

0 or blank = none
1 = one hypoplasia
2 = two or more
3= not observable

Use left teeth preferentially and only report clearly discernible hypoplasias.

Catalogue Number:_____
Original Number:_____
Acc. Number:_____

Hurst Data Collection Form

Description of remains:
Age/Sex:_____
Location/Excavator:_____
Usable sample? (ie mummified tissue, broken orbits):_____

Scoring Anterior

Pore Size:_____

Pore Density:_____

Porosity % Affected:_____

Diploic Expansion:_____

Vascular Channels:_____

Plaques/Plaque Size:_____

Plaque Size:_____

Scoring Posterior

Pore Size:_____

Pore Density:_____

Porosity % Affected:_____

Diploic Expansion:_____

Vascular Channels:_____

Plaques/Plaque Size :_____

Diagnosis:_____

Hypoplastic Defects:

ULM3:	ULM1:	ULP3:	ULI2:
ULM2:	ULP4:	ULC:	ULI1:

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