Nutrition and Health in the Piedmont of North Carolina and Virginia: A Bioarchaeological Study

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# ABSTRACT

Carson Elizabeth Rouse: Nutrition and Health in the Piedmont of North Carolina and Virginia: A Bioarchaeological Study

**Nutrition and Health in the Piedmont of North Carolina and Virginia**

This study focuses on changes in nutrition and health in three past populations that inhabited the Piedmont of North Carolina and Virginia. The people who lived at the three localities-- Town Creek, Stockton, and Fredricks -- date to the late prehistoric and early colonial time periods. In order to reconstruct the health of these populations, I examined forty-nine individuals to estimate age and sex, and for lesions that serve as evidence of disease or nutritional deficiency. The indicators of health fall into one of three categories: oral health, dietary deficiencies, and general indicators of disease or stress. I specifically looked for changes to oral environment including alveolar infections, tooth loss, and cavities. In order to assess dietary deficiencies, I observed indicators of scurvy, rickets and anemia which are often manifested in lesions on specific bones. Finally, other indicators of health such as osteomyelitis and periosteal reactions were noted as general indicators of health insult. I hypothesize that populations inhabiting the North Carolina and Virginia Piedmont became healthier after colonization due to shifts away from an agricultural diet that were brought about by increasing mobility and economic changes associated with colonial encounters.

# Chapter One: Piedmont North Carolina and Southern Virginia

## Piedmont of North Carolina and Southern Virginia

According to the North Carolina Commission of Indian Affairs, there were more than 80,000 Indian People living in North Carolina as of 2001 which is about 1.2% of the state's overall population. The majority of the Indian population (39%) resides in Robeson County which is located in the Piedmont region of the state. Although much is known historically about current Indian inhabitants of the Piedmont, little is known about the past native inhabitants of this area (Price 2001, xii-xiii). According to James H. Merrell, the Piedmont natives were peoples who historically "lived and died in obscurity, an obscurity that, for the most part, has continued to this day" demonstrating the lack of information pertaining to the native peoples of Piedmont North Carolina and Southern Virginia (Merrell 1987, 20).

In order to disclose further details of the lives of North Carolina's past peoples, I examined for this thesis the skeletal remains of forty-nine individuals from three Piedmont sites located in North Carolina and Southern Virginia. These include Town Creek Indian Mound (Mg2-3), Stockton (Vir231), and Fredricks (Or231). These skeletal series were selected because they provide information relative to both the prehistoric and early historic periods. The main focus of this thesis is to examine the changes in health of the native populations, specifically with regard to diet and metabolic diseases to help shed light on the lives of these past people.

The bioarchaeology of metabolic diseases can reveal a great deal about the lives of past peoples (Brickley and Ives 2008, 1). Brickley and Ives, in their 2008 book, *The Bioarchaeology of Metabolic Bone Disease,* define metabolic bone disease as bone modeling and remodeling that is disrupted due to disease. Studying these changes in bone growth and regrowth can reveal concepts such as the lifestyle, culture, diet, socio-economic status, and environments of past peoples (Brickley and Ives 2008, 1).

In addition to metabolic bone disease, I also examined oral health changes and general stress indicators because they could indicate underlying changes in health due to diet during specific time periods. Changes in the oral health environment can indicate changes in diet and nutrition in past peoples. General stress indicators are skeletal and dental lesions for which the exact etiology may be unknown. They differ from metabolic disease indicators because their origin may or may not be related back to nutrition and diet but instead can be linked back to sources such as genetics. They include periosteal reactions, osteomyelitis, and enamel hypoplasias. Although the exact cause of these lesions in the human body varies, there is abundance of evidence that they increase in frequency with urbanization and with the transition to agriculture (Roberts and Manchester 2005, 173).

A prime example of this increase in frequency can be seen in Clark Spencer Larsen's study of prehistoric populations from the Georgia Coast (Larsen 1984, 367). He focused on disease-nutritional stress by looking for periosteal reactions and dental caries, and mechanical stress by looking for degenerative joint disease (Larsen 1984, 367-368). He examined nineteen preagricultural and fourteen agricultural groups. The preagricultural group had a sample of 272 individuals while the agricultural group had a sample of 368 individuals (Larsen 1984, 368). Before A.D. 1150, the populations on the Georgia Coast primarily relied on hunting, gathering, and fishing for their main sources of food. After A.D. 1150, they began to cultivate crops, primarily maize. By comparing these groups for evidence of disease-nutritional stress and mechanical stress, Larsen concluded that there was a decline in health with the switch from preagricultural to agricultural groups evidenced by the increase in periosteal reactions (Larsen 1984, 387-388). Based on these three categories, I hypothesis that the overall health of the individuals increased during the historic period due to contact with the Europeans affecting their foodways and lifestyles.

In 2000, Patricia M. Lambert published a study of 649 individuals from thirteen sites throughout the Piedmont of North Carolina and Virginia as part of a NAGPRA inventory project, including Town Creek Indian Mound, Stockton, and Fredricks (Lambert 2000, 169). She observed dental caries, cribra orbitalia, scurvy, iron-deficiency anemia, periosteal reactions, treponematosis, tuberculosis, and enamel hypoplasias (Lambert 2000, 174).

She noted that there was an increase in dental caries during the prehistoric period, but a decrease in dental caries during the protohistoric and historic periods. She also noted that the frequency of infectious diseases such as treponemotosis and tuberculosis decreased after contact with Europeans (Lambert 2000, 192). In contrast to these results, the number of enamel hypoplasias increased during the Contact Period (Lambert 2000, 185). Based on these varied results, Lambert concluded that, “variation within this region further suggest that variables such as resource distribution, quality of arable land, microclimatic variability, and unique cultural practices influenced heath and thus the quality of life in various regions of North Carolina and Virginia” (Lambert 2000, 192).

The study I report here goes beyond that conducted by Lambert by integrating the archaeological evidence for foodways with that of the health markers I observed and which are frequently associated with diet and nutrition. I further place those data within the context of cultural change, and distribution brought about by the colonial process.

## Geographic Background for Piedmont North Carolina-Southern Virginia

Piedmont North Carolina is located between the coastal plain and the Blue Ridge Mountains. Piedmont Virginia is located between the Potomac River and the Blue Ridge Mountains. The Piedmont is a "highly dissected plateau that contains some 20,000 square miles" (Ward 1983, 53-54). Its elevation spans from 400 to 2,000 feet above sea level. The landscape of this area consists of rolling hills and ridges that run from the northeast to the southwest. Although the topography is fairly consistent throughout the Piedmont, there are a few abnormalities such as Kings Mountain in Cleveland and Gaston counties, North Carolina. A plethora of resources were available to the native inhabitants of this area including an abundant lithic supply, abundant plant and animal resources, many waterways to aid in travel and trade, and fertile soil for growing crops (Ward 1983, 54-56).

## Maize Agriculture in the Piedmont

Around A.D. 200, maize began to be seen in the archaeological record of the United States. However, it was not until about A.D. 1000 that maize became a staple crop in the Piedmont of North Carolina and Southern Virginia. Around A.D. 1200 true agricultural systems began to develop throughout the East (Ward and Davis 1999, 78). Although maize is believed to have been important to the diet of native peoples in Piedmont North Carolina and Virginia, "botanical and faunal remains recovered from archaeological sites of this region suggest a diverse economy anchored in varying degrees to maize" (Ward and Davis 1993, 1999; Lambert 2000, 165).

A study published in 1996 by Trimble demonstrated that stable isotope carbon levels varied across North Carolina through time. For example, the Donnaha site (A.D.1040-1480) had carbon values of about 15.8% while the Koehler site (A.D. 1300-1400) in Virginia showed levels of carbon at about 19.1% (Trimble 1996 cited in Lambert 2000, 169). Based on Trimble's results, it is apparent that there was an increasing reliance on maize during the prehistoric period in the Piedmont. However, "there is some archaeological evidence for a return to a more mixed economy perhaps as a result of fur trade activities, in the protohistoric/ historic period" [Ward and Davis 1993, 1999 cited in Lambert 2000, 170).

## **Historic Account of the Piedmont**

Although there is only some early historic information pertaining to the indigenous peoples of the Piedmont, one of the most famous historic accounts of the Piedmont is contained in John Lawson's 1709 book: "A New Voyage to Carolina." Little is known of Lawson's personal background until he journeyed to the New World in 1700. Lawson states that a gentleman had informed him that "*Carolina* was the best Country I could go to; and, that there then lay a Ship in the *Thames,* in which I might have my passage. I laid hold on this Opportunity, and was not long on Board" (Lefler 1967, 7).

Once he arrived in Charles Town, South Carolina, the Lord Proprietors entrusted him with the task of surveying the Carolina colony's interior. Only a few Spanish and English traders and explorers had ever ventured into the backcountry of the colony, so Lawson had to rely on Native American guides to lead him and his party through the colony's interior. They led him on a northerly route to present day North Carolina following the famous trading path near Charlotte, Concord, Hillsborough and Salisbury. He claimed he travelled about 1000 miles; however, recent scholarly work indicates that he only travelled about 550 miles during this trip (Lefler 1967, xv).

As he traveled, Lawson kept a detailed journal including diary entries, notes about the flora and fauna, and translations of the native language. In the chapter, "An Account of the Indian of North Carolina," Lawson described the lives of the native peoples he encountered on his journey by explaining their customs, burial practices and foodways. He lists the wide variety of foods that they ate including "Bear and Bever; Panther; Pole-cat; Wild-cat; Possum; Raccoon; Hares; and Squirrels" (Lefler 1967,182). In addition, he emphasized the use of shell-fish and gourds as well as their reliance on flora such as maize, potatoes, acorns (Lefler 1967,182). According to Lawson, there were "no Indians having greater plenty of Provisions than these. The Savages do, indeed, still possess the Flower of Carolina," (Lefler 1967, 61).

Based on Lawson's observational notes, it appears that resources were abundant and were readily available for the native populations to achieve an adequate diet. This maintenance of an adequate diet would hinder the occurrence of metabolic bone diseases in the populations because they stem from inadequate nutrition. Although Lawson's history paints a crude picture of the lives of the native inhabitants of North Carolina during the turn of the 18$^{th}$ century, the osteological information reported in this paper provides additional information regarding the lives and diets of the past native populations of North Carolina.

## **Archaeological Background**

According to some scholars, North Carolina archaeology truly commenced when archaeologists began to excavate the Piedmont in the early 1930s. The North Carolina Archaeological Society was founded in 1933, and the first statewide survey was conducted in

1934. The Piedmont was divided in those early years into zones to be surveyed by individuals including Douglas Rights, Guy B. Johnson, and Joffre Coe. The main goal of these initial surveying expeditions was to learn more information and find historic towns associated with the Siouan groups such as the Keyauwee site located in Randolph County, North Carolina.

Following World War II, the focus of archaeological work in the Piedmont shifted to attempting to find earlier sites (Ward 1983, 57-59). And finally, in the 1970s another major archaeological shift occurred in North Carolina. The "passage of national conservation legislation emphasizing cultural resource management (CRM)" began to be the main focus of archaeology (Ward 1983, 59). Researchers began to focus on survey and settlement studies with the main excavations being test operations (Ward 1983, 59-60). The three sites described below (chosen for this study) serve witness to the archaeological efforts that were an outgrowth of that early research.

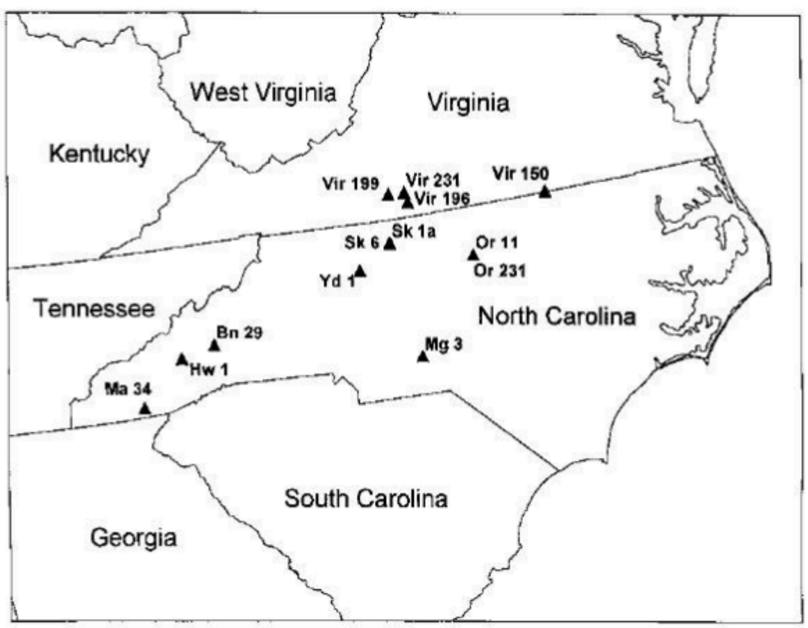


Figure 10-1. Location of Archaeological Sites. (Map generated by R. P. Stephen Davis)

Fig.1 Map of Sites from (Lambert 2000, 173)

## Archaeological Sample

**Town Creek Indian Mound (Mg2-3)**

Town Creek Indian Mound is an archaeological site located on the Little River in Southern Montgomery County, North Carolina. This site is associated with the Pee Dee culture and contained a ceremonial mound, a plaza and village center (Cunningham 2010, 1). Excavations at this site began in 1937 under the supervision of Joffre Coe, an undergraduate student at the University of North Carolina at Chapel Hill. The excavations were associated with the Work Progress Administration, the State Museum, and University of North Carolina at Chapel Hill (Coe 1995, 31). The site was excavated intermittently and a reconstruction of the site was completed in 1964. Coe remained in charge of research at the site until his retirement in 1982 (Ward and Davis 1999, 13).

Two types of dating were used at this site: radiocarbon and fluorine testing. Twenty-six radiocarbon samples were taken from Pee Dee sites throughout North Carolina in an attempt to establish an accurate chronology (Cunningham 2010, 13). Four of these samples were taken from Town Creek. In addition, fluorine testing was attempted to date Town Creek. Multiple periods of occupation have been noted at this site: Late Woodland-period occupation (A.D. 800-1000), Teal-Phase Occupation (A.D. 1000-1150), Early Town Creek Phase Occupation (A.D. 1150-1250), Late Town Creek and Leak Phase Occupations (A.D. 1250-1350), and Caraway Phase Occupation (A.D. 1550-1700). Fluorine testing is a relative dating technique that measures the amount of fluor-apatite in the skeletal materials absorbed from the soil and ground mixture. It is believed that the amount of fluor-apatite will continue to accumulate over time, allowing researchers to put burials in relative chronological order. However, a study conducted by Driscoll in 2001 demonstrated that this dating method did not work at Town Creek because the levels of fluoride in the environment were too low to gain accurate fluor-apatite (Cunningham 2010,12-13).

There are 563 identified burials at Town Creek Indian Mound, but only 239 of them have been excavated (Cunningham 2010, 10). Of those excavated, seven came from the Yadkin group, fourteen came from the proto-historic Siouan group and 218 of them came from the Pee Dee Culture (Cunningham 2010, 10). The burials were often single inhumations found in the floors of buildings surrounding the plaza, but some were buried within the mound and others were buried in open areas of the site (Cunningham 2010, 11). In addition, the types of burials varied greatly at this site. Most of the individuals were "loosely flexed," however, some of them were fully extended. In addition, infants and subadults were often wrapped and buried in burial urns (Ward and Davis 1999, 124).

Town Creek Indian Mound became an important ceremonial and ritual center for the Pee Dee culture (Ward and Davis 1999, 133). Although some researchers originally believed that the site was only occupied by religious leaders and that Pee Dee Native Americans were only allowed to visit the site, archaeological evidence such as the large presence of refuse, postholes and multiple stockades indicates that this site also had a substantial residential population. Archaeological evidence indicates maize agriculture was the main source of food, but hunting, fishing, collecting and growing plant foods such as hickory nuts, walnuts, acorns, squash, and beans also contributed significantly to the diet (Ward and Davis 1999, 244; Cunningham 2010, 10).

**Stockton (Vir231)**

Stockton is an archaeological site located in Henry County, Virginia and dates to the Dan River phase (A.D. 1000-1450) (Davis et al. 1997, 1). This site was originally discovered by R.D. Harris Jr. in 1967 after uncovering artifacts such as potsherds and shells while plowing the land for a field (Davis et al. 1997, 1). Excavation of the site began in March 1969 and was conducted mainly by Richard P. Gravely Jr. and R.D. Harris. Work on the site was conducted intermittently until June 1970 (Davis et al. 1997,1).

The site is circular in shape and contained sixty-six archaeological features (approximately 250 postholes were also discovered but were not labeled as features). Twenty-three of these features were burials. Most of these were simple pit burials, with a few shaft-and-chamber burials. Each of the pit burials was filled with soil, ash, and refuse. The majority of the burials were located on the southwestern edge of the site. Fourteen were oriented facing the east, which was a common trend in Dan River drainage sites (Davis et al. 1997, 7-17).

The archaeological evidence for past diet is limited at this site because the flora and faunal remains have yet to be analyzed. Gravely kept detailed records of the features, however, and noted that some of the common faunal remains found included “white-tailed deer, turkey and other birds, turtle, and fish. Bear and wolf also [were] mentioned” (Davis et al. 1997, 4). Pots with corncob imprints were also found indicating maize was present. The Stockton (Vir231) inhabitants likely grew “maize, squash, gourd, and beans” as well as, “sunflower, goosefoot, sumpweed, and maygrass” (Davis et al. 1997, 4). In addition, their diet could have also included small animals such as raccoons and beavers (Davis et al. 1997, 4-5).

**Fredricks (Or231)**

Fredricks is an archaeological site located in Orange County, North Carolina near the Eno River. This site is believed to be an Occaneechi village established after these natives had to migrate from their settlement on the Roanoke River (Dickens, Ward, and Davis 1987, 1). Originally the Occaneechi people had control over multiple trade endeavors (such as deerskin trade) from Georgia to Virginia because of their strategic settlement location on the Roanoke River. In 1676 Bacon's Rebellion, a civil war broke out in the Virginia Colony between Governor William Berkeley and Nathaniel Bacon over how to handle conflicts with the neighboring Native American tribes (Rice 2014, 728). Bacon and his followers eventually began to attack groups of Indians, which led to a war with the Susquehannocks, a neighboring tribe (Rice 2014, 730). Soon the Susquehannocks took refuge near the Occaneechi settlement on the Roanoke River. The Occaneechi sent word to Virginia about the location of the Susquehannocks and assisted in the attacks on two of their forts. Although the attacks on the Susquehannocks were well coordinated between the Occaneechi and Virginia colonists, a dispute broke out between the two groups leading to the death of one hundred Occaneechi (Rice 2014, 737-738). The tribe was unable to maintain and protect their island settlement, so they migrated to present day Hillsborough, North Carolina (Dickens, Ward, and Davis 1987, 2). This new site was occupied between A.D. 1680 and 1710 and is believed to be the last major village of the Occaneechi tribe (Dickens, Ward, and Davis 1987, 1).

The Fredricks site (Or231) was excavated between 1983 and 1986 as part of a larger project called the Siouan Project that had as its the goal "elucidation of culture change among

Indian groups of the North Carolina-Southern Virginia Piedmont during the historic period" (Dickens, Ward, and Davis 1987, 1).

During the first field season at Fredricks in 1983, researchers discovered a plethora of European artifacts such as scissors, knives, and glass beads, and aboriginal artifacts such as shell gorgets, shell beads, and ceramic vessels. Rectangular pits with post holes and four burial pits which contained three sets of human remains were also found at the site. Each of the pits with skeletal remains also had grave goods within them (Dickens, Ward, and Davis 1987, 14). However, these graves did not follow the pattern of burials seen in surrounding sites potentially indicating a "depopulation from European diseases" (Driscoll, Davis, and Ward 2001, 130). A second cemetery was found in 1989 and a third was discovered in 1995 and 1996 (Driscoll, Davis, and Ward 2001, 130). All three cemeteries were similar in age and sex composition (Driscoll, Davis, and Ward 2001, 136).

In addition to the burial and structural data collected during these field excavations, multiple features also included food remains, which serve to inform us of the diet of these past people. Large amounts of corn and corn kernels were found indicating that agriculture was a large staple in the diets of these people. Multiple types of seeds were found including maypops, sumac and hickory nutshells, acorns, peach pits, walnut shells. There was also evidence of animals including turtle, raccoon, deer, bear, fox and horse (Merrell 1987, 63-71).

## **Materials and Methods**

The skeletal and dental remains of the individuals excavated at the three sites (Mg2-3, Vir 231, and Or231) are currently curated by the Research Laboratories of Archaeology at the University of North Carolina at Chapel Hill. Each of these skeletal series was separately studied macroscopically to estimate age and sex and for indications of oral health and dietary deficiency. Sixteen individuals were studied from Town Creek (Mg2-3), twenty-two were examined from Stockton (Vir231), and eleven were examined from Fredricks (Or231) for a total of forty-nine individuals examined for this thesis.

Age estimation was performed using methods detailed in *Standards: For Data Collection From Human Skeletal Remains* (Buikstra and Ubelaker, 1994). Dental development and eruption was used to estimate age for subadults. If dentition was unavailable, then the subadult age was estimated using epiphyseal union. For adults, age was determined using the auricular surface of the innominate. If the auricular surface estimate was unavailable (due to missing elements or poor preservation), age estimation was performed by analysis of the pubic symphysis. When possible, these age estimations were compared to those obtained by studying the sternal rib ends (Buikstra and Ubelaker 1994, 21-44). All age estimations were grouped into one of five categories (table 1) (Boudreaux 2005, 270).

Table 1: Age Categories

| **Age Categories** | **Age Ranges:** |
|---|---|
| Child | 5 years old or younger |
| Adolescent | 6-14 years old |
| Young Adult | 15-24 years old |
| Mature Adult | 23-34 years old |
| Older Adult | 35+ years old |

Sex estimation was only conducted for the adult samples (twenty years or older) because "skeletal material [for sex estimation] is most accurate after the individual reaches maturity" (White and Folkens 2005, 385). The Phenice method developed in 1996 was used to estimate the sex of the individuals by analyzing the ventral arc, subpubic concavity, and the medial aspect of the ischiopubic ramus (White and Folken 2005, 395-397). If the Phenice method could not be used on the sample (due to missing elements or poor preservation), then visual estimations of the crania and innominates using methods described in Standards book (Buikstra and Ubelaker 1994, 18-21).

The skeletal samples were then macroscopically examined for pathological lesions, new bone formation, drainage holes, etc. These lesions (as described in chapter two) were then organized within one of three groups: metabolic stress indicators, indicators of oral health, and general stress indicators. All of the pathological indicators that are associated with one of these three categories can possibly be related in some way back to the diet of the native inhabitants of the Piedmont. Additional pathological lesions not necessarily related to diet, such as treponemal infection, were also noted and will be described later in this paper because research has indicated a synergistic relationship between infectious diseases and nutritional disease (Goodman, Martin, Armelagos and Clark 1984, 33), and they can provide information on the overall health of the individuals in the Piedmont.

# Chapter Two: Osteological Evidence for Changes in Health

## Metabolic stress indicators

The forty-nine individuals from the three sites were examined macroscopically for potential metabolic stress indicators. These indicators include porotic hyperostosis and cribra orbitalia, and pathological lesions indicative of scurvy and rickets. Each of these indicators can be attributed to poor nutrition and can indicate major changes in the health of these native individuals due to dietary deficiency.

### Porotic Hyperostosis and Cribra Orbitalia

Porotic hyperostosis and cribra orbitalia are defined as lesions found on the cranial vault and eye orbits that, in their most extreme expression, have a hair-on-end appearance. When found on the cranial vault, the lesions are referred to as porotic hyperostosis. When found on the orbital roofs, the lesions are referred to as cribra orbitalia. Some researchers believe that the lesions on the cranial vault are indicators of a more severe case of poor nutrition (Roberts and Manchester 2005, 230-231). The cause of these lesions is iron deficiency anemia.

Anemia is categorized as a "reduction in the concentration of hemoglobin and/ or red blood cells below the normal for the age and sex of the person" (Roberts and Manchester 2005, 226). There are often large stores of iron in the liver and spleen of an individual, but because 90% of the iron in old blood cells is needed to create new blood cells, these stores can be depleted quickly if an individual does not have enough iron in their diet (Roberts and Manchester 2005, 226).

There are two forms of iron that are found in foods. The first type is non-haem and is often found in cereals such as maize. Non-haem iron is only absorbed through the intestines and they often do not absorb much of it. The other form of iron found in diets is haem iron. This form of iron is consumed when an individual eats red meats and vegetables, and it is more easily absorbed (Roberts and Manchester 2005, 226). Researchers often believe that populations switching from hunter-gather to agriculture could have caused increases in iron-deficiency anemia because of the decrease in haem and the increase in non-haem in these past populations' diets (Roberts and Manchester 2005, 226).

Because of this lack of iron, the diploe in the cranial vault often thickens in size due to the bone marrow attempting to compensate for the lack of red blood cells caused by the low levels of iron in the blood stream. This thickening creates lesions with a hair-on-end appearance on the parietals and the occipital bone. Some types of anemia that could cause porotic hyperostosis and cribra orbitalia are hereditary, such as thalassemia and sickle cell anemia (Goodman, Martin, Armelagos, and Clark 1984, 29). The most common form of anemia, however, is acquired iron-deficiency anemia -- as of 2005, it was found in over 500 million people worldwide (Roberts and Manchester 2005, 226). Skeletal changes due to this anemia often only occur during an individual's childhood but can remain present into their adult life (Roberts and Manchester 2005, 229).

**Scurvy**

Scurvy is the "clinical manifestation of vitamin C deficiency" (Roberts and Manchester 2005, 234-235). Vitamin C, or ascorbic acid, plays an essential role in the formation of collagen. Because collagen is fundamental for bone formation, evidence of scurvy can best be seen in the skeletons of infants because of their rapid growth rate.

Although it is most common in infants, vitamin C deficiency does not manifest until the infant is about four months old because the infant has stores of vitamin C from the mother (Ortner 1985, 270).

A prolonged vitamin C deficiency causes increased bleeding beneath the surface of the skin and the membrane around the bones. This deficiency also affects the binding agents in the blood vessels, causing increased bleeding in the soft tissue which can lead to new bone formations in the affected areas. In addition to these new bone formations (often in the long bones), small lesions on the skull have also been attributed to vitamin C deficiencies (Roberts and Manchester 2005, 235-236).

Subadults suffering from a vitamin C deficiency tend to have bilateral lesions on the greater wings of the sphenoid, maxilla and orbital plate. Researchers believe that these lesions are associated with the temporalis muscle. This muscle is located next to the sphenoid. Between the muscle and the sphenoid bone are two temporal arteries. These arteries can be affected by the lack of vitamin C and hemorrhaging would likely occur causing an inflammatory action between the muscle, the sphenoid and the posterior portion of the maxilla and orbital plate. This inflammatory action can lead to the lesions that researchers see on subadults (Ortner and Ericson 1997, 212-220).

Although many mammals have the ability to synthesize vitamin C, anthropoid primates lost this ancestral trait due to a mutation of the L-gulono--lactone oxidase (*GLO*) gene, thus causing humans to have to obtain vitamin C through food and drink (Drouin, Godin and Page 2011, 371-373). To prevent the development of these skeletal manifestations, researchers recommend that individuals consume 30mg of vitamin C per day to prevent the onset of scurvy; however, these levels may vary across age, sex, and ethnicity

(Brickley and Ives 2008, 47-48). A prolonged lack of vitamin C often can have lasting effects on the skeleton. Vitamin C is found in fresh fruits and uncooked vegetables, and small amounts can be found in milk, meat, and fish (Brickley and Ives 2008, 41).

In addition, a study conducted by Geber et al. focused on scurvy in individuals who died during The Great Famine (1845-1852) in Ireland (Geber and Murphy 2012, 512). The potato was a major source of food for the poor in Ireland during the mid-1800s and contains very high amounts of Vitamin C. For example, "freshly dug potatoes hold approximately 30 mg of Vitamin C per 100 g of edible matter" (Geber and Murphy 2012, 514). When a blight destroyed the potato crop, a "widespread occurrence of infectious and metabolic diseases" and "mass starvation" occurred throughout the population (Geber and Murphy 2012, 512). Of the 970 individuals they examined, 16% of them had evidence of scurvy (Geber and Murphy 2012, 512), demonstrating the relationship between scurvy and changes in diet.

**Rickets**

Vitamin D deficiency can also have a lasting effect on an individual's skeleton but not related to direct mortality (Ortner 1985, 273). Most individuals obtain the necessary vitamin D through exposure to sunlight, which is a precursor to vitamin D production, and a supplemental diet of items such as eggs, fortified milk, liver, and oily fish (Brickley and Ives 2008, 75). Although the duration of sun exposure is debated, most researchers believe that five to fifteen minutes of exposure to sunlight should provide individuals with enough vitamin D to be healthy. The amount of vitamin D needed in an individual's diet varies based on location, sex, and skin pigmentation (Brickley and Ives 2008, 85).

When an individual does not get the necessary exposure to sunlight, or has a dietary deficiency or a heritable disease, their bone formation is affected due to prolonged lack of vitamin D (Brickley and Ives 2008, 9). Vitamin D is necessary in the mineralization of osteoid during bone formation and is also important in maintaining homeostatic calcium levels (Brickley and Ives 2008, 75). Vitamin D deficiencies do not manifest until the child is at least four months old because the nutrients were passed from the mother and child through the placenta. Children are most often affected between six months and two years (Ortner 1985, 274). Often these indicators peak when the subadult is three to eighteen months old (Brickley and Ives 2008, 91).

In children, severe vitamin D deficiencies can cause malformation of the weight-bearing elements of the skeleton, such as changes to the pelvis and bowing of the long bones (Brickley and Ives 2008, 92). The ribs can also be affected, causing the ends of the ribs to flair. In addition, some of the long bones might have flaring bone growth (Brickley and Ives 2008, 92). Vitamin D deficiency can also cause porosity in the cranial bones and growth plates (Brickley and Ives 2008, 91). These skeletal manifestations are often categorized as Rickets in subadult skeletons.

When adults experience prolonged vitamin D deficiencies they also develop severe symptoms like subadults, but the condition is referred to as osteomalacia. Because a lack of vitamin D prevents mineralization of osteoids, adult individuals who suffered from this deficiency tend to have muscle and bone deformity on the pelvis and hip bones. In addition, they may develop pseudofractures on their bones (Brickley and Ives 2008, 114-118).

## Oral Health

The forty-nine individuals were also macroscopically examined for indicators of degenerative oral health. The indicators of oral health include carious lesions, periodontal disease and ante-mortem tooth loss, and alveolar infections. Each of these indicators can be attributed to poor nutrition and can indicate major changes in the health of these native skeletal series due to changes in diet.

### Dental Caries

The presence of dental carious lesions (or cavities) can indicate major changes in the oral environments of individuals potentially caused by changes in diet. Dental caries is a process defined as the, “destruction of enamel, dentine and cement resulting from acid production by bacteria in dental plaque, ultimately leading to the formation of a cavity in the crown or root surface” (Hillson 1996, 269)**.** The lesions (cavities or dental carious lesions) are the most reported dental disease in archaeology and range from small opaque spots to large cavities that extend into the pulp cavity of the tooth, and can be found on both the crowns and the roots of the teeth (Roberts and Manchester 2005, 65).

There are multiple potential causes for dental carious lesions. Mary Powell divided these causes into four categories: environmental factors, pathogenic agents, exogenous facts and endogenous factors (Roberts and Manchester 2005, 65). In addition, dental problems can also be a factor for the development of dental carious lesions because they can weaken the teeth and severe wear can increase the likelihood that bacteria could get inside the pulp cavity causing the decay (Roberts and Manchester 2005, 66). However, the most commonly referred to cause of caries is the presence of large amounts of sugar in the diet of the individual. The sugars are fermented on the surface of the tooth by bacteria such as

*Lactobacillus acidophilu*s and *Streptococcus mutans* (Roberts and Manchester 2005, 65). This fermentation process causes microbial action of the teeth that can lead to the demineralization of the tooth. This demineralization allows the tooth to be susceptible to the development of dental carious lesions (Roberts and Manchester 2005, 65).

Certain aspects of an individual's life may also make them predisposed to developing dental carious lesions. Miura et al. (1997) conducted a cross-national study of dental caries and determined that the number of dental carious lesions increased significantly if the individual lived in an urban area (Miura et al. 1997 in Roberts and Manchester 2005, 65). In addition, low levels of fluoride in the surrounding environment may also make the individual more susceptible to cavities. Also, multiple studies have been conducted that have concluded that the likelihood of an individual developing cavities increases with age as well as their gender and status within the environment (Roberts and Manchester 2005, 67).

Finally, there appears to be a correlation between cavities and agricultural societies. Clark Larsen conducted a study in 1984 of the Georgia coast to compare pre-agricultural (1000 BC-A.D. 1150) and agricultural (A.D. 1150-1550) communities. In his study, he noted that there appeared to be a 10% increase in dental caries in all tooth types across genders in the shift from pre-agricultural to agricultural societies. Larsen believed that the main cause of this increase stemmed from the increase in sucrose in their diet caused by maize becoming a main staple in their diets (Roberts and Manchester 2005, 67).

**Periodontal Disease and Ante-Mortem Tooth Loss**

Periodontal disease is also a very common dental disease (although not as common as dental caries) seen in the archaeological record. Periodontal disease is a disease that affects the periosteal tissue surrounding the mouth. The periosteal tissue includes the periodontal ligament, cement, gingivae, and mucosa (Hillson 1996, 260). Having large traces of calculus between the gums and the teeth often are a predisposing factor for the development of the disease. Initially this disease begins with gingivitis, or the inflammation of the gums. Then, if it spreads past the three initial stages (initial lesion, early lesion and established lesion), it then enters into the fourth stage: advanced lesion. When the last stage is reached, the disease is then classified as periodontis instead of gingivitis. Once in the periodontal stage, all of the periosteal tissue around the infected tooth are affected (Hillson 1996, 262-263). It affects the bones and can lead to the loss of the periodontal ligament that holds teeth in their place. Eventually the gap between the tooth and bone grow so much that the tooth is lost (Hillson 1996, 262-263).

Many researchers believe that it is hard to identify periodontal disease in the archaeological record because there is no standardized method of identifying this disease. Some archaeologists even argue that periodontal disease is over-diagnosed within the archaeological record. However, the presence of healing around the tooth socket or bone growth in the empty tooth socket are two major indicators of the disease in the archaeological record (Roberts and Manchester 2005, 73).

**Alveolar Infection**

Alveolar infection (also known as dental abscess) occurs when bacteria gets inside the pulp cavity of the tooth from either a cavity or trauma. When the bacteria enter the pulp cavity, inflammation begins and is frequently later associated with an accumulation of pus (Roberts and Manchester 2005, 70). As more pus collects, small amounts of it may escape through the root canals (Hillson 1996, 286). However, when large enough amounts of pus accumulate, small holes (cloaca) form in the jaw bones for the pus to escape. Often a smoothwalled lesion forms around the roots which are indicative of an alveolar infection. However, researchers indicate that bone damaged post mortem may mimic these abscesses and that researchers should also look for evidence of healing around the bone as an indicator of alveolar infection (Roberts and Manchester 2005, 70-71).

## General Stress Indicators

Furthermore, the forty-nine individuals were macroscopically examined for general stress indicators. The one stress indicator examined in this paper is enamel hypoplasias The exact cause of this general stress indicator is unknown, but studies have been conducted that show an increase in hypoplasias with urbanization and the shift to agricultural societies. In addition, the presence of general stress indicators may be positively correlated with both metabolic bone diseases and changes in oral health. Other stressors, such as infections and inflammatory responses, also can be related back to the diet of the skeletal series.

### Dental Enamel Hypoplasia

Enamel is the hard mineralized substance that encapsulates the crown of human teeth. It is formed by the soft tissue epithelium which is, “a sheet of closely and regularly packed cells called ameloblasts” in two stages (Hillson 1996, 148). During matrix secretion crystallites and minerals combine to grow and during maturation the ameoloblasts break down the organic matter in the matrix to make the teeth mineralize (Hillson 1996, 148-149).

There are multiple different causes of dental enamel hypoplasias that can be grouped into, “hereditary anomalies, localized trauma, and systemic metabolic stress such as nutritional deficiency or a childhood illness” (Goodman and Rose 1991 in Roberts and Manchester 2005, 75). Dental enamel hypoplasias associated with malnutrition or disease can often be found on the canines or incisors of skeletal remains. If an individual experienced starvation or a major disease when the enamel of their teeth was still developing (during their childhood), slight lines, grooves or pits may have formed on their teeth, which are categorized as enamel defects (Larsen and Hutchinson 1992, 151-169). Enamel defects are thus interpreted as non-specific indicators of stress in an individual's life (Roberts and Manchester 2005, 75).

There are three suspected causes of the formation of hypoplasias during childhood: genetic abnormalities, trauma, or metabolic stress. Although there are three possible causes for the development of dental enamel hypoplasias, cases of hypoplasias caused by genetic abnormalities and trauma are rare in the archeological realm because those individuals have a significantly lower chance of survival which would not give the defect enough time to manifest on the enamel surface. Because of that low chance of survival, the majority of dental enamel hypoplasia (especially linear enamel hypoplasia) cases in archaeology are thought to be caused by metabolic stress (Goodman and Rose 1990, 59-110).

When there is a period of stress or trauma, such as a fever, lack of nutrients, or hormonal changes, for an individual, they cause disruptions with the ameloblasts production of the enamel matrix, which manifests as dental enamel hypoplasias in the individual (Hillson 1986, 130). The severity of these hypoplasias corresponds with the length of the stress or trauma that the individual went through (Goodman and Rose 1990, 59-110). For example, if an individual had a severe illness, the hypoplasia might manifest in a wave-like pattern which corresponds to the severe periods of the illness.

Some researchers also believe that these periods of stress that could have caused dental enamel hypoplasias in past populations might have been influenced by changes in diet. Larsen's research indicates that changing from a diet focused on hunting and gathering society to one focused on agriculture increased stress and created an influx of enamel hypoplasias in native populations in Georgia (Roberts and Manchester 2005, 75-76). These periods of stress often cause dental enamel hypoplasia and can often reveal stress related to changes in diet in past populations.

## Infectious Disease

### Sinusitis

Sinusitis is defined as an infection of the throat, ear, nasal sinuses, or chest. Although this infection was probably very common in past populations, it is difficult to diagnose in the archaeological record because the "nasal sinuses are air-filled cavities within the bone of the face and are therefore difficult to inspect (Roberts and Manchester 2005, 174). However, if the air-filled cavities are exposed in the archaeological record, then sinusitis can be identified by irregular pitting or new bone formation within the sinuses (Roberts and Manchester 2005, 174).

One study conducted by Roberts *et al.* at St Helen-on-the-Walls in York, England found that 72% of the individuals in their sample suffered from maxillary sinusitis. This high percentage may arise from a correlation between sinus infections and dental caries. When a tooth is severely infected, the infection can spread into the sinuses thus allowing sinusitis to occur. In addition, sinusitis has been shown to occur more often in urban sites than in rural sites (Roberts and Manchester 2005, 174-175).

### Periosteal Reaction

Periostitis or periosteal reaction is a non-specific bone inflammation that can be manifested in "fine pitting, longitudinal striation and, eventually, plaque-like new bone formation on the original cortical surface" (Roberts and Manchester 2005, 172). Although periosteal reactions are often interpreted as non-specific stress indicators, they are often associated with infectious disease process.

There can be multiple causes for periosteal reactions within the body. Some reactions can occur through trauma while others can occur through an infection in the body. Although there are multiple potential causes for periosteal reactions, the tibia is the most commonly affected bone in the human body. Many researchers believe that this bone is mainly affected because it is so close to the skin surface, allowing it to be susceptible to trauma. Others argue that, because the bone is so close to the skin surface, the temperature of the bone is cooler thus creating a "physiologically inactive surface, leading to bacterial colonization" and "blood tends to stagnate in the lower legs, allowing bacteria to accumulate" (Roberts and Manchester 2005, 172-173).

**Osteomyelitis**

Osteomyelitis is a nonspecific disease indicator that occurs in the body and affects the marrow of bones (Ortner 1985, 112), but like periostitis it is often associated with specific disease processes. It is often characterized by bone destruction, pus formation and simultaneous bone repair (Roberts and Manchester 2005, 168-169). Bacteria from outside sources, usually spreading to the bone through the bloodstream from an infection of the throat nose, is the major cause of osteomyelitis; however, the bacteria can also enter the bloodstream through a penetrating bone injury, skin ulcers, trauma, or surgery.

*Staphylococcus aureaus* is the bacteria responsible for 90% of present day cases of osteomyelitis (Ortner 2003 cited in Roberts and Manchester 2005, 171). The infection spreads to the marrow of the bone creating pressure within the diaphysis. This pressure leads to necrosis of the cortex of the bone. The dead bone is turned into the sequestrum and the body begins to produce new bone growth around the sequestrum (Ortner 1985, 112). This new bone is made by osteoblasts in the periosteum and lacks microstructure, causing the new bone to be labeled as 'woven bone.' In extreme cases, the original bone underneath the newly formed bone can die, thus forcing the new and less efficient bone to support the the body (Roberts and Manchester 2005, 168-17). In conjunction with the bone necrosis and regrowth, within the bone, pus abscess fill the cavities of the bone. These abscesses can escape through the involucrum and soft tissue which cause distinctive cloaca to form on the bone (Ortner 1985, 113).

Evidence of osteomyelitis is mainly found on the femura and tibiae about 80% of the time and about 10% is found on the humerus. Other long bones, tubular bones, cancellous bones, and the skull have also been reported but are more rarely affected (Ortner 1985, 111).

**Treponemal Infection**

There are four different types of treponemal infection: venereal syphilis, nonvenereal (endemic) syphilis, yaws and pinta. These infections are caused by bacterial spirochetes: *Treponema carterum, Treponema pallidum pertenue, Treponema pallidum pallidum,* and *Treponema pallidum endemicum,* respectively (Larsen 1997, 94). An individual contracts these infections by coming into contact with the lesions of another individual. Once the infection is in the body, it spreads through the circulatory system. The initial stage of the infection begins with a "mild inflammatory lesion" (Roberts and Manchester 2005, 208). The progression of pinta stops with lesions on the skin and does not affect the skeleton, thus it was unable to be examined for this study. The second stage for the remaining three types of infections- yaws, venereal, and nonvenereal syphilis-creates changes to the soft tissues. The later stage then causes the destruction and reconstruction of bones. This process is a form of osteomyelitis (Roberts and Manchester 2005, 208).

In yaws, the most commonly affected element is the tibia. New bone formation creates a woven bone pattern on the bone. This new bone growth causes the tibia to have a 'saber-shin' appearance. In addition, irregular depressions may form on the cranial vault, maxilla, and nasal bones (Larsen 1997, 94-95). This bone involvement occurs in about 5-15% of all cases of yaws (Roberts and Manchester 2005, 208).

Similar to yaws, the bones of the nasal region and upper jaw can also be affected in nonvenereal syphilis. In addition, the tibiae may also be affected creating the 'saber-shin' appearance. The amount of bone involvement increases in nonvenereal syphilis to between 15-20%. The major difference between nonvenereal syphilis and yaws depends on the environment. Yaws tends to manifest in humid, tropical environments while nonvenereal syphilis manifests in more arid regions (Roberts and Manchester 2005, 209). In addition, nonvenereal syphilis tends to manifest stellate lesions on the cranial vault and some consider these lesions, "the best single criterion for endemic treponematosis" in specific regions (Larsen 1997, 97).

Venereal syphilis is probably the most debated disease in history (Roberts and Manchester 2005, 201) because researchers disagree whether it originated in the New World or the Old World (Larsen 1997, 95). In venereal syphilis, the osteological changes may develop between two and ten years after the individual contracted the disease. The tibiae may also form the 'saber shin' appearance. But unlike yaws, it also can cause malformations of the elbow, hip, knee joint, and many other bones in the body. In addition, the skull is often commonly affected as well with *caries sicca,* or stellate lesions, forming along the frontal and parietal bones.  About 20% of bones are involved in venereal syphilis (Roberts and Manchester 2005, 208).

One major difference between venereal syphilis and the other forms of the infection is that the disease can be transferred from a mother to the fetus. The infection that the subadult contracts is called congenital syphilis and crosses the placental boundary from the infected mother to the child. It causes growth disruption in several elements, including the tibia and the teeth (Larsen 1997, 95).

## Chapter Three: Results

### Osteological Evidence of Metabolic Disease in the Piedmont

Of the forty-nine individuals examined for this thesis, 30.6% of them had evidence of metabolic bone disease consistent with inadequate diets. Of this 30.6%, about 5% suffered from cribra orbitalia, 17% suffered from porotic hyperostosis, 23% suffered from vitamin C deficiency and none appeared to suffer from a vitamin D deficiency as seen in Table 2. This next section will take a closer look at the specific occurrences of metabolic bone disease and what elements were affected.

Table 2: Frequency of Metabolic Bone Disease

| The Frequency of Metabolic Bone Disease | Total Number Observable | Total Number with Affected | Percent Affected |
|---|---|---|---|
| Cribra Orbitalia | 39 | 2 | 5.128% |
| Porotic Hyperostosis | 41 | 7 | 17% |
| Scurvy | 42 | 6 | 14.29% |
| Rickets | 42 | 0 | 0% |

### Cribra Orbitalia

Table 3 shows that two individuals (5%) had lesions consistent with cribra orbitalia on at least one eye orbit of the frontal bone. These lesions were small and had a slight "hair on end" appearance. These two individuals, burials 11 and 22, both came from Stockton (Vir231) and ranged in age from about two years old to about 5 years old (Table 4; Appendix II). The presence of these lesions demonstrates that about 10.5% of the individuals examined for Stockton (Vir231) had evidence of an anemia.

Table 3: Frequency of Cribra Orbitalia

| Individuals with Cribra Orbitalia | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 10 | 0 | 0% |
| Stockton (Vir231) | 19 | 2 | 10.53 |
| Fredricks (Or231) | 10 | 0 | 0% |

Table 4: Individuals with Cribra Orbitalia

| Site | Individuals | Age Category | Sex | Elements Affected | Clarifying Notes |
|---|---|---|---|---|---|
| Vir231 | 11 | Subadult (2 ± 8 months) | n/a | Frontal bone | Lesions in right eye orbit |
| Vir231 | 22 | Subadult (5± 16 months) | n/a | Frontal bone, zygomas | Lesions in right eye orbit |

**Porotic Hyperostosis**

Although there was only slight evidence of anemia with the presence of cribra orbitalia in the three series examined, there was a larger proportion of individuals that exhibited porotic hyperostosis (Table 5). Seven individuals (17%) exhibited lesions on the cranial vault that were consistent with the diagnosis of porotic hyperostosis. These individuals ranged in age and sex estimations as seen in Table 6. One subadult exhibited lesions consistent with porotic hyperostosis. Three young adults, one mature adult, and two older adults also had lesions consistent with porotic hyperostosis. There were four females and two males that exhibited evidence of porotic hyperostosis.

At Town Creek Indian Mound (Mg2-3), one individual (8.33%), individual 5, had heavily remodeled of porotic hyperostosis lesions on the left and right parietal bones along the sagittal suture. This individual was an adolescent about 12-16 years old. In contrast to Town Creek (Mg2-3), five individuals (26.32%) from Stockton (Vir231) had lesions consistent with porotic hyperostosis on the cranial vault. These individuals all exhibited porotic hyperostosis on the cranial vault in various degrees. Individuals 1, 3 and 8 had porotic lesions extensively along the cranial vault while individual 5 only had slight lesions on the right parietal bone. Finally, individual 13 had evidence of porotic hyperostosis lesions along the sagittal suture on both the left and right parietals. In summary, 26.3% of the individuals studied from Stockton (Vir231) that could be examined for porotic hyperostosis lesions exhibited evidence of iron deficiency. Of those affected, four were females and one was a male.

Finally, one individual (10%) from Fredricks (Or231) also had evidence of porotic hyperostosis on. Individual 3 was a young adult male about 20-24 years old who had extensive lesions along both parietal bones and along the frontal bone. In total, 10% of the individuals examined for Fredricks had evidence of iron deficiency.

Table 5: Frequency of Porotic Hyperostosis

| Individuals with Porotic Hyperostosis | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 12 | 1 | 8.33% |
| Stockton (Vir231) | 19 | 5 | 26.32% |
| Fredricks (Or231) | 10 | 1 | 10% |

Table 6: Individuals with Porotic Hyperostosis

| Site | Individual | Age Category | Sex | Elements Affected |
|---|---|---|---|---|
| Mg2-3 | 5 | Subadult | n/a | Left and right parietals, occipital extensive |
| Vir231 | 1 | Young adult | Female | Frontal, right parietal, and occipital |
| Vir231 | 3 | Older adult | Female | Frontal, very slight left and right parietals |
| Vir231 | 5 | Young adult | Female | Left and right parietals |
| Vir231 | 8 | Older adult | Male | Frontal, left and right parietals, and occipital |
| Vir231 | 13 | Mature adult | Female | Left and right parietals |
| Or231 | 3 | Young adult | Male | Frontal and left and right parietals [1] |

**Scurvy**

As seen in Table 7, six individuals had evidence of scurvy. Three of the individuals from Town Creek (Mg2-3), 4, 10 (Fig. 2), and 36, (23%) showed evidence of scorbutic lesions that ranged from localized lesions such as the ones from individual 36 (Fig. 3), found along the parietal bones, to widespread lesions such as the ones seen with individual 4 (Fig. 4), who had extensive lesions on the frontal bone, sphenoid fragments, and temporal bones (Table 8). That latter case could indicate a more severe case of vitamin C deficiency.

[1] Colors refer to site in all tables: yellow is Town Creek (Mg2-3), blue is Stockton (Vir231), and orange is Fredricks (Or231)

Fig. 2: Mg2-3 Individual 10, scorbutic lesions on eye orbits

Fig. 3: Mg2-3 Individual 36, scorbutic lesions on parietal

Fig. 4: Mg2-3 Individual 4, scorbutic lesions on eye orbit

Table 7: Frequency of Scurvy

| Individuals with Scurvy | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 13 | 3 | 23.08% |
| Stockton (Vir231) | 19 | 2 | 10.53% |
| Fredricks (Or231) | 10 | 1 | 10% |

At Stockton (Vir231), individuals 7 and 8 also exhibited lesions that were consistent with a vitamin C deficiency. These two individuals out of the nineteen observable for scurvy like lesions make up 10.53% of the individuals examined for this study. Individual 7, a subadult, had evidence of scurvy on the frontal bone while individual 8, an older adult male, had lesions suggestive of scurvy on left and right temporal bones, parietal, and zygomas as well as on the frontal bone. In addition, there appeared to be scorbutic nodes on the mandible; however, there were no scurvy-like lesions on either side of the ascending ramus, which is a common location for lesions indicating a vitamin C deficiency.

Only one individual (10%) from Fredricks appeared to have lesions consistent with a vitamin C deficiency. Individual 2, a subadult, appeared to have an extensive case of scurvy as shown by the scorbutic bone that formed on the right side of the mandible. In addition, there were scorbutic lesions on both sides of the medial ascending ramus. Lesions were also found on the sphenoid, temporal bones, near foramen magnum, and zygomas, all frequent locations for the hemorrhage associated with scurvy. Postcranial lesions include denser bone formed on the ulna, fibula, a few ribs and the atlas and axis, which can be analogous with a vitamin C deficiency.

Table 8: Individuals with Scurvy

| Site | Individual | Age Category | Sex | Elements Affected |
|---|---|---|---|---|
| Mg2-3 | 4 | n/a | n/a | Frontal bone, sphenoid fragments, and temporal bones |
| Mg2-3 | 10 | Subadult | n/a | Frontal bone |
| Mg2-3 | 36 | Mature adult | female | Parietal bones |
| Vir231 | 7 | Subadult | n/a | Frontal bone |
| Vir231 | 8 | Older adult | Male | Left and right temporal bones, parietal bones and zygomas |
| Or231 | 2 | Subadult | n/a | Right side of mandible |

**Rickets**

Although all of the individuals in this study were examined for evidence of rickets, none of the individuals had any of the key indicators suggesting a vitamin D deficiency (Table 9). Such changes include pelvic deformation, potential bowing in the long bone, and the flaring of rib ends. One individual, individual 4 from Stockton (Vir231), did have bowing of the arm bones (Fig. 5 and 6). However, this bowing could be due to mechanical stress and thus was not included in the analysis of a vitamin D deficiency.

The absence of evidence for rickets may be partly due to the fact that many of the remains were incomplete in all of the skeletal series, which is common archaeologically. Often many of the long bones were missing from the burials I examined. For example, individual 7 from Fredricks (Or231) was lacking the majority of the remains except partial tibias and femurs. This lack absence of elements could indicate the reason why there was no evidence of rickets on any of the individuals. In addition, the subadults suffering from a vitamin D deficiency may have passed away before changes to the skeleton could have occurred, thus making it impossible to see any deficiency in the skeletal remains.

Fig. 5 Vir 231 Individual 4 bowed radii

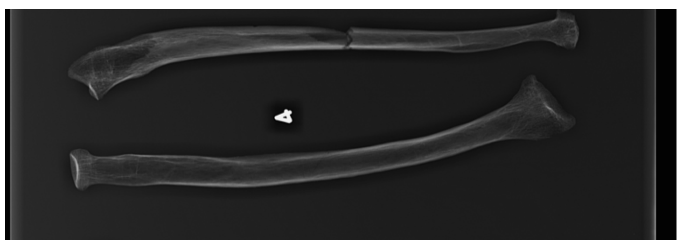

Fig. 6 Vir231 Individual 4, x-ray of bowed radii

Table 9: Frequency of Rickets

| Individuals with Rickets | Total Number of Individuals with Rickets |
|---|---|
| Town Creek (Mg2-3) | 0 |
| Stockton (Vir231) | 0 |
| Fredricks (Or231) | 0 |

## Osteological Evidence of Changes to Oral Health Environments in the Piedmont

### Dental Carious Lesions

Thirty individuals (Appendix I) from the three sites had at least one cavity (Table 10). Six of these individuals were children and adolescents, nine were young adults, thirteen were mature adults, and two were older adults. Twelve of these individuals were female and seven were male. The rest of the individuals were either subadults for whom sex estimates were not attempted (seven individuals) or there was not enough of the skeleton preserved for an accurate sex estimation to be made for older individuals (four individuals).

Nine individuals (56%) from Town Creek (Mg2-3) had at least one cavity. There was one male, three females, and five sex indeterminate because they either a subadult or not enough of the skeletal materials were available to make an accurate sex estimation. At Stockton (Vir231) thirteen individuals (59%)- eight females, four males and one indeterminate- had at least one cavity. Eight individuals (72%) from Fredricks (Or231) had at least one cavity. Of these eight individuals, four of them were too young to have accurate sex estimates, one was not complete enough to have an accurate sex estimation, two were male, and one was female. The number, the size, and the location of these cavities varied throughout the individuals.

Table 10: Frequency of Dental Carious Lesions

| Individuals with Dental Carious Lesions | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 12 | 9 | 75% |
| Stockton (Vir231) | 17 | 13 | 76.47% |
| Fredricks (Or231) | 10 | 8 | 80% |

**Periodontal Disease and Ante-Mortem Tooth Loss**

Of the forty-nine individuals examined, eighteen (43.9%) showed evidence of ante-mortem tooth loss as seen in Table 11. This ante-mortem tooth loss was identified through the presence of additional bone growth around empty teeth sockets (Fig. 7). Ten of these individuals were female, five were male, and three were of indeterminate sex due either to age or lack of remains to accurately estimate sex. Four (28.5%) of these individuals were from Town Creek. From Stockton, thirteen individuals (65%) showed evidence of ante-mortem tooth loss and one individual (10%) from Fredrick, individual 5, showed evidence of ante-mortem tooth loss.

(Table 11).

Table 11 Frequency of Ante-Mortem Tooth Loss

| Individuals with Ante-Mortem Tooth Loss | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 14 | 4 | 28.57% |
| Stockton (Vir231) | 20 | 13 | 65% |
| Fredricks (Or231) | 10 | 1 | 10% |

Table 12: Individuals with Ante-Mortem Tooth Loss

| Site | Individual | Age Category | Age | Sex | Location of Ante-Mortem Tooth Loss |
|---|---|---|---|---|---|
| Mg2-3 | 6 | Child | 4-5 years | n/a | Left and right mandible (m1,m2) |
| Mg2-3 | 8 | Mature Adult | 28+ | Female | Left and right mandible (m1,m2) |
| Mg2-3 | 27 | Mature Adult | mid 20s | Female | Left and right mandible (m1,m2) |
| Mg2-3 | 41 | Young Adult | 16-22 | Female | Left mandible (m1,m2, m3) |
| Vir231 | 1 | Young adult | 20-24 | Female | Right mandible (pm4, m1,m2,m3) |
| Vir231 | 3 | Older adult | 38.2 ±10 | Female | Left and right mandible (m1,m2,m3) |
| Vir231 | 5 | Young Adult | 20 | Female | Right mandible (pm4, m1,m2,m3) |
| Vir231 | 6 | Mature Adult | About 30 | n/a | Left mandible (m1,m2) |
| Vir231 | 8 | Older Adult | Mid 30s | Male | Left maxilla (m2,m3) |
| Vir231 | 13 | Mature Adult | 24-32 | Female | Left mandible (m1,m2,m3) right mandible (pm4, m1,m2,m3) |
| Vir231 | 14 | Mature Adult | 24-32 | Female | Left mandible (m1,m2) right mandible (m1,m2) |
| Vir231 | 15 | Mature Adult | 24-28 | Male | Left maxilla (m1,m2,m3), right maxilla (m1,m2,m3) Left mandible (m1) Right mandible (pm4,m1,m2,m3) |
| Vir231 | 18 | Mature Adult | About 25 | Female | Right mandible (pm3,pm4, m1,m2,m3) |
| Vir231 | 20 | Mature Adult | 25-28 | Male | Left mandible (i1,i2,c,pm3,pm4,m1,m2m, 3) |
| Vir231 | 21 | Mature Adult | 25-29 | Male | Right mandible (m1,m2) |
| Vir231 | X | Young Adult | 21-24 | Female | Left mandible (all teeth) right mandible (i1,i2,c,pm3) |
| Vir231 | 22 | Subadult | Around birth | n/a | Right maxilla (il) |
| Or231 | 5 | Young Adult | 22-24 | Male | All teeth on both sides of maxillae |

Fig. 7 Vir231 Individual 13 Ante-Mortem Tooth Loss

**Alveolar Infection**

Over 30% of individuals examined (Table 13) had evidence of an alveolar infection ranging from a slight infection of one tooth (such as individual 1b from Town Creek (Mg2-3) to more severe cases affecting multiple teeth on both the mandible and maxillae (such as individual 9 from Stockton (Vir231) that had the infection underneath eight teeth). All of the individuals that showed evidence of at least one alveolar infection were young adults or older. There were no cases of subadults having evidence of alveolar infections. The severity of the infections appeared to varied between the sites. At Town Creek (Mg2-3), four individuals (33.3%) showed evidence of an alveolar infection (Table 14).

Table 13: Frequency of Alveolar Infection

| Individuals with Alveolar Infection | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 12 | 4 | 33.33% |
| Stockton (Vir231) | 17 | 12 | 70.59% |
| Fredricks (Or231) | 10 | 3 | 30% |

Table 14: Individuals at Town Creek (Mg2-3) with Alveolar Infections

| Site | Individual | Age Category | Age | Sex | Location of Alveolar Infection |
|---|---|---|---|---|---|
| Mg2-3 | 1B | Mature adult | 31+ | Male | Left mandible |
| Mg2-3 | 27 | Mature adult | mid 20s | Female | Left and right mandible |
| Mg2-3 | 36 | Mature adult | 25-29 | Female | Left and right maxillae |
| Mg2-3 | 41 | Young adult | 16-22 | Female | Left and right mandible |

Table 15: Individuals at Stockton (Vir231) with Alveolar Infections

| Site | Individual: | Age Category: | Age: | Sex: | Location of Alveolar Infection: |
|---|---|---|---|---|---|
| Vir231 | 1 | Young adult | 20-24 | female | Right mandible (c, pm3) |
| Vir231 | 3 | Older adult | 38 ± 10 | Female | Left mandible(c) |
| Vir231 | 5 | Young adult | 16-22 | Female | Left maxilla (pm4, m2) right maxilla (c, m1, m2) |
| Vir231 | 6 | Mature adult | 30 or slightly younger | n/a | Right maxilla (pm3, m1,m2,m3) left mandible (m2) right mandible (i1, m1,m2) |
| Vir231 | 8 | Older adult | mid 30s | male | Right maxilla (m1,m2) |
| Vir231 | 9 | Young adult | 20-24 | female | Left maxillae (c, pm3), Right maxilla (pm4, m2,m3) Left mandible (m1) Right mandible (m1, m3) |
| Vir231 | 13 | Mature adult | 24-32 | female | Right maxilla (c,pm3,pm4,m1,m2,m3), left mandible (m1,m2,m3) right mandible (i1,i2,c) |
| Vir231 | 14 | Mature adult | 30+ | Female | Left maxilla (pm3, pm4), left mandible (c), |
| Vir231 | 15 | Mature adult | 24-28 | Male | Left maxilla (c), left mandible (pm3, pm4), right mandible (c, pm3, pm4) |

| | | | | | |
|---|---|---|---|---|---|
| Vir231 | 18 | Mature adult | 25 | Female | Left maxilla (pm3), right Maxilla (pm3, pm4, m1, and m2), |
| Vir231 | 21 | Mature adult | 25-29 | Male | Right maxilla (canine, pm3, pm4), right mandible (i2) |
| Vir231 | 22 | Subadult | Around birth | n/a | Left and right mandible and maxillae |

Twelve individuals out of seventeen, or 70.5%, examined from Stockton (Vir231) showed evidence of alveolar infections on either the maxillae or mandible (Table 15).

Three individuals (30%) from Fredricks (Or231) suffered from alveolar infections. This means that 30% of the individuals examined from Fredricks (Or231) had evidence of at least one alveolar infection (Table 16).

Table 16: Individuals at Fredricks (Or231) with Alveolar Infections

| Site | Individuals | Age category | Age | Sex | Location of alveolar infection |
|---|---|---|---|---|---|
| Or231 | 3 | Young adult | 20-24 | Male | Left maxilla (c, m1) right maxilla (i1,i2,c) |
| Or231 | 4 | Mature adult | 35+ | Female | Left maxilla (m1,m2,m3) right mandible (m2, m3) |
| Or231 | 5 | Young adult | 22-24 | Male | Left mandible (m1,m2,m3) right mandible (c, pm3, pm4) |

## Osteological Evidence of General Stress Indicators in the Piedmont

**Dental enamel hypoplasia**

Four individuals (Table 18) (8.3%) showed lines, grooves, or pits consistent with dental enamel hypoplasias (Table 17). One individual from Town Creek (Mg2-3), individual 29, had hypoplasias on the right maxillary incisors. The three other individuals (30%) with linear enamel hypoplasias came from Fredricks (Or231) and were individuals 2, 6, and 11. Individual 2 had hypoplasias on the left and right first mandibular incisor and one on the left mandibular first molar. Individual 6 had hypoplasias on the left and right first and second maxillary incisor and canines of mandible on both sides. Finally, individual 11 had hypoplasias on the first and second incisor and canines on both maxillae and right mandible. The left half of the mandible only had one hypoplasia on the left canine. These four individuals make up about 10% of the total sample studied.

Table 17: Frequency of Dental Enamel Hypoplasias

| Individuals with Dental Enamel Hypoplasias | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 12 | 1 | 8.33% |
| Stockton (Vir231) | 17 | 0 | 0% |
| Fredricks (Or231) | 10 | 3 | 30% |

Table 18: Individuals with Dental Enamel Hypoplasias

| Site | Individual | Age Category | Sex | Elements Affected |
|---|---|---|---|---|
| Mg2-3 | 29 | Mature adult | n/a | right maxillary I1 |
| Or231 | 2 | Subadult | n/a | Left and right mandibular I1, mandibular m1 |
| Or231 | 6 | Subadult | n/a | Left and right mandibular I1 |
| Or231 | 11 | Subadult | n/a | right mandibular and maxillary I1,I2, c |

## Osteological Evidence of Infectious Diseases in the Piedmont

### General Lesions

### Sinusitis

Of the thirty individuals examined for this study, ten (33.3%) showed evidence of maxillary sinus infections (Table 19). Only one individual (41) from Town Creek Indian Mound (Mg2-3) had evidence of a sinus infection indicating that only about 12.5% of the observable individuals from this site examined suffered from this infection. In contrast, eight individuals (Table 20) showed evidence of sinus infections in their maxillae, which makes up about 61.5% of the individuals from Stockton (Vir231). Finally, one individual (5), from the observable nine individuals (11.11%) from Fredricks (Or231) had evidence of a sinus infection indicating that about 9% of the individuals examined from Fredricks suffered from a sinus infection.

Table 19: Frequency of Sinusitis

| Individuals with Sinusitis | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 8 | 1 | 12.5% |
| Stockton (Vir231) | 13 | 8 | 61.54% |
| Fredricks (Or231) | 9 | 1 | 11.11% |

Table 20: Individuals with Sinusitis

| Site | Individual | Age Category | Sex | Elements Affected |
|---|---|---|---|---|
| Mg2-3 | 41 | Young Adult | Female | Maxilla |
| Vir231 | 3 | Older Adult | Female | Maxilla |
| Vir231 | 6 | Mature Adult | n/a | Maxilla |
| Vir231 | 8 | Older Adult | Male | Maxilla |
| Vir231 | 9 | Young Adult | Female | Maxilla |
| Vir231 | 10 | Young Adult | n/a | Maxilla |
| Vir231 | 12 | Child | n/a | Maxilla |
| Vir231 | 15 | Mature Adult | Male | Maxilla |
| Vir231 | 22 | Child | n/a | Maxilla |
| Or231 | 5 | n/a | Male | Maxilla |

**Periosteal Reaction**

Of the forty-four individuals examined for this study that had long bones and/or patellae present, seventeen (38.6%) showed evidence of periosteal reactions (Table 21). Four individuals (30.7%) from Town Creek showed evidence of these reactions on at least one bone. Twelve individuals showed evidence of periosteal reactions on at least one bone from Stockton (Vir231), which is about 60% of the individuals studied from this site. Finally, one individual (4) from the eleven observed at Fredricks (Or231) showed evidence of periosteal reactions, which is about 9% of the skeletal series examined (Table 22).

Table 21: Frequency of Periosteal Reactions

| Individuals with Periosteal Reactions | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 13 | 4 | 30.77% |
| Stockton (Vir231) | 20 | 12 | 60% |
| Fredricks (Or231) | 11 | 1 | 9.09% |

Table 22: Individuals with Periosteal Reactions

| Site | Individual with Periosteal Reactions | Age Category | Age | Sex | Number of Elements | Elements |
|---|---|---|---|---|---|---|
| Mg2-3 | 1B | Mature Adult | 31+ | Male | 2 | Left and right tibiae |
| Mg2-3 | 6 | Child | 4-5 | n/a | 2 | Left and right femur shaft |
| Mg2-3 | 8 | Mature Adult | 28+ | Female | 1 | Right innominate |
| Mg2-3 | 31 | Adolescent | 6±24 months | n/a | 4 | Left radius, left femur, left tibia, right tibia |
| Vir231 | 4 | Young Adult | 23+ | Female | | Patellae |
| Vir231 | 6 | Mature Adult | mid to late 20s | n/a | 1 | Right patella |
| Vir231 | 8 | Older Adult | mid 30s | Male | 2 | Patellae |
| Vir231 | 9 | Young adult | 20-24 | Female | 2 | Left tibia, left fibula |
| Vir231 | 11 | Child | 2+-8 months | n/a | 8 | Tibiae, humeri, radii, ulnas |
| Vir231 | 14 | Mature Adult | 30+ | Female | 1 | Left patella |
| Vir231 | 15 | Mature Adult | 24-28 | Male | 4 | Ulnas, patellae |
| Vir231 | 17 | Young Adult | 20-24 | Female | 1 | Right patella |
| Vir231 | 18 | Mature Adult | 25 | Female | 4 | Tibiae, patellae |
| Vir231 | 20 | Mature Adult | 25-28 | Male | 2 | patellae |
| Vir231 | 21 | Mature Adult | 25-29 | Male | 3 | Patellae and right tibia |
| Vir231 | X | Young Adult | 21-24 | Female | 2 | Tibiae |
| Or231 | 4 | Mature Adult | 30+ | Female | 1 | Right patella |

**Osteomyelitis**

Of the forty-three individuals examined for this study, only four individuals (20%), all from Stockton (Vir231), had evidence of new bone formation consistent with osteomyelitis (Table 23). Individual 8 (Table 24) had new bone formation on the right femur and left tibia, left humerus and a fibula (unable to be sided due to lack of both proximal and distal ends of the bone). Individual 9 had new bone growth on the left femur and left tibia and the left fibula. There was also a cloaca on the left tibia of this individual. Individual 13 has new bone formation on the scapula, patellae, clavicles, tibiae, and femur (Fig. 8), as well as a cloaca on the tibia (Fig. 9). Individual 15 had new bone formation on a femur, tibia, humerus, and radius (Fig. 10).

Table 23: Frequency of Osteomyelitis

| Individuals with Osteomyelitis | Total Number Observed | Total Number Affected | Percent Affected |
|---|---|---|---|
| Town Creek (Mg2-3) | 12 | 0 | 0% |
| Stockton (Vir231) | 20 | 4 | 20% |
| Fredricks (Or231) | 11 | 0 | 0% |

Table 24: Individuals with Osteomyelitis

| Site | Individual | Age Category | Sex | Elements Affected |
|---|---|---|---|---|
| Vir231 | 8 | Older Adult | Male | Both tibiae, left humerus and fibula |
| Vir231 | 9 | Young Adult | Female | Left femur, tibia and fibula |
| Vir231 | 13 | Mature Adult | Female | Scapula, patellae, clavicles, tibiae, femur |
| Vir231 | 15 | Mature Adult | Male | Femur, tibia, humerus radius |

Fig. 8: Vir231 Individual 13 osteomyelitis of a right femur


Fig. 9 Vir231 Individual 13 osteomyelitis of tibiae with cloaca


Fig. 10 Vir231 Individual 8 osteomyelitis of fibula, tibia and humerus

**Specific Lesions**

Based on the presence of stellate lesions on the cranial vaults, individuals 8 and 15 appear to have suffered from a treponemal infection, which was manifested in the osteomyelitis in the long bones. Individual 8 also had sclerotic nodes on the mandible, consistent with a treponemal infection. At least six stellate lesions were located on the cranial vault along the parietals and frontal bones (Fig. 12). Although the left tibia did not have the “saber-shin” appearance, there was evidence of systemic infection with bone reformation on the diaphysis of the bone. Individual 15 had at least seven of these stellate lesions across the parietals and frontal bone (Fig. 11). In addition, the new bone formation on the right tibia had the classic “saber-shin” appearance.

With the presence of these changes in the bones, it is evident that these two individuals suffered from a treponemal infection due to the location of the sites, stellate lesions, and the “saber-shin” of individual 15 and the history of the disease. The other two individuals, 9 and 13, lacked stellate lesions and thus were not placed in the treponenmal infection category. However, these two individuals could have been suffered from a treponemal infection and had not yet reached the tertiary stage of the disease and thus the manifestation of the stellate lesion would not have occurred yet. Additional diagnostic identification studies need to be conducted on these two individuals to conclude or rule out a treponemal infection.

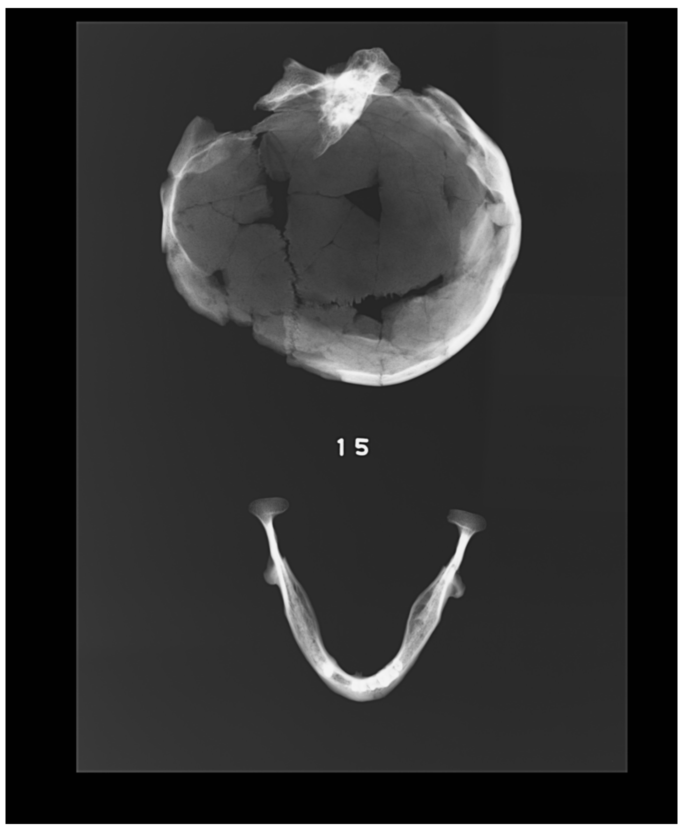


Fig.11: Vir231 Individual 15 stellate lesions and nodes

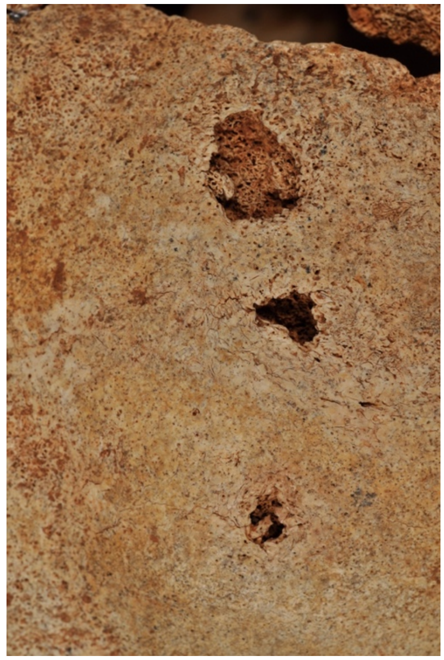

Fig. 12: Vir231 Individual 8 cranial caviations prior to the formation of stellate lesion

## Chapter Four: Conclusion

### Effect of Changing Diet on the Native Populations of the Piedmont

According to Brickley and Ives, the fundamental goal of bioarchaeology is to "determine[ing] the extent to which disease also affected past populations" (Brickley and Ives 2008, 1). This study focused on three categories of potential indicators of health: metabolic disease indicators, indicators of poor oral health, and general disease indicators. Although this was a small sample, based on the osteological evidence at these three sites, it is apparent that there were some indicators of metabolic disease, oral health, and general disease indicators. Due to the synergistic interaction between infectious diseases and nutrition, the presence of these indicators may reveal information about the diet and lifestyles of these past populations.

**Metabolic Diseases**

According to Goodman, Martin, Armelagos, and Clark, "subsistence systems may allow for greater population density, [and] subsistence intensification may result in lower quality of diet for each person and amplify interpersonal strife as access to quality nutrients is limited" (Goodman, Martin, Armelagos and Clark 1984, 15). The archaeological evidence at each site demonstrated that maize contributed significantly to the overall diet. Because of the history of the three sites, indications of metabolic stress on these individuals would be expected. A small number, about 30.6% of the individuals examined, showed any metabolic stress indicators. I hypothesized that the presence of these metabolic stress indicators would decrease after contact with Europeans because of the high amount of tribal mobility.

My examination of the metabolic health of the skeletal series indicates that diet may have had negative effects on the overall health on those living at the three sites examined in this paper. However, the total number of individuals suffering from the nutritional deficiencies examined in this study is relatively low compared to other studies of Southeast Woodland skeletal series in North Carolina as seen in Table 25.

Table 25: Comparative Studies
(Hutchinson 2002; and Lambert 2000) [2]

| Disease | Percent Affected in my Study | Comparative Studies | Percent Affected in Comparative Studies |
|---|---|---|---|
| Cribra Orbitalia | 5.13% | Lambert 2000 | 23-63% |
| Porotic Hyperostosis | 17.07% | Hutchinson 2002 | 21% |
| Scurvy | 14.29% | Lambert 2000 | 23-63% |
| Cavities | 76.92% | Lambert 2000 | 14.3-83.3% |
| Alveolar Infection | 48.7% | Hutchinson 2002 | 20% |
| Premortem Tooth loss | 40.9% | Lambert 2000 | 14.3-83.3% |
| Sinus Infection | 33.3% | Roberts 2007 | 38.6% |
| Periosteal Reaction | 38.6% | Lambert 2000 | 37.5% |
| Osteomyelitis | 12.5% | Hutchinson 2002 | 5% |
| Enamel Hypoplasia | 10.25% | Lambert 2000 | 80% |

This low frequency may result from the fact that although the cultivation of maize for some native inhabitants' diets began around A.D. 1000, it did not make up the entire diet of the individuals in the Piedmont. All three of the sites had archaeological evidence of additional food sources such as wild vegetation and meat that could have provided sufficient

[2] This table represents just a few of the multiple studies conducted of the health of Southeast Woodland skeletal series. Hutchinson's 2000 book *Foraging, Farming and Coastal BioCultural Adaptation in Late Prehistoric North Carolina* includes data from Mark Teaford, Lynette Norr, Ann M. Kakaliouras, and Theresa Schober . Lambert's 2000 study described in *Bioarchaeological Studies of Life in the Age of Agriculture: A View from the Southeast* included data from Trimble 1996; Martin et al. 1991; R.P. Stephen Davis 1998; Davis et al. 1997, Research Laboratories of Archaeology 1996; and Ward and Davis 1999.

nutritional resources. Botanical and faunal analyses have not been completed at these sites to determine the amount of maize that these individuals were consuming.

Four individuals from Town Creek (Mg2-3) had evidence of metabolic disease indicators. The individuals examined at Stockton (Vir231) suffered the most from metabolic disease with nine individuals suffering from either iron deficiency or vitamin C deficiency and only two individuals from the colonial Fredricks skeletal series had evidence of metabolic disease indicators. The frequent presence of metabolic diseases at Stockton (Vir231) may be related to the time periods and culture of the settlement.

Town Creek was inhabited from A.D. 800-1650, and was part of the Mississippian Culture (Lambert 2000, 170). Although there was an abundant amount of evidence indicating that maize formed a large part of the diet, the settlement of this site before the introduction of maize agriculture may have allowed traditions and foodways to have already been established in the society which may have allowed for other nutrient rich food products to be included in the diet.

In contrast to Town Creek (Mg2-3), Stockton (Vir231) was occupied around A.D. 1000-1450 indicating that the settlement was founded at the same time maize agriculture was becoming prominent in the Piedmont. The settlement of the site at this time may indicate that the diet of these people was contingent on agricultural practices that included the cultivation of maize. This theory is supported by the evidence that, "the importance of maize is thought to have increased throughout the late prehistoric period" (Ward and Davis 1993, 1999 cited in Lambert 200, 170). In addition, this site was associated with the Woodland culture which could explain the differences between this site and Town Creek (Mg2-3). The cultural differences between the two sites may have also played a major role in the differences in metabolic bone disease

Only two individuals from Fredricks had evidence of metabolic diseases. This low number may be attributed to the fact that the site of Fredricks (Or231) differs drastically from the other two sites because the individuals from Fredricks had contact with Europeans. Fredricks was occupied between A.D. 1680 and 1710 during the Contact period with the European settlers and explorers (Merrell 1987, 19-20). As discussed in many other bioarchaeological studies and ethnographies, contact with Europeans led to dramatic changes to the native populations throughout America. These native populations lacked the natural immunities to deadly diseases such as smallpox and measles which soon became epidemic diseases to these native inhabitants (Merrell 1987, 19-29).

According to Lawson's accounts, one in every six Native Americans survived smallpox (Lawson 1967, 20). In addition, many researchers have noted the relationship between poor diet and the ineffectiveness of one's immune system. Individuals who have poor diets often have immune systems which are compromised because the majority of the body's energy is being used to compensate for the inadequate diet, thus leaving the individual open for infectious diseases (Roberts and Manchester 2007, 223). Based on the prevalence of European diseases that were raging during the occupation of Fredricks and the low number of individuals with metabolic disease indicators, many individuals from Fredricks (Or231) may have died before skeletal lesions indicative of inadequate nutrition could have formed.

In addition, the history of Fredricks (Or231) indicates that the population had to move because of interactions with Europeans. This resettlement may have prevented the population of Fredricks from over relying on agriculture as their main source of food because of the constant instability of the lifeways during the Contact period in American history. Lawson's notes support this hypothesis with his entry that stated, "Their Cabins were hung with a good sort of Tapestry, as fat Bear, and barbakued or dried Venison; no Indians having greater plenty of Provisions than these. The Savages do, indeed, still possess the Flower of Carolina," (Lawson 1967, 61). Because so few individuals from Fredricks (Or231) in comparison to Stockton (Vir231) suffered from these nutritional deficiencies, other factors such as interaction with Europeans, changes in culture, or other variables may also be a key factor in these differences.

Based on the results of the metabolic disease indicators at these three sites, it is evident that the presence of these indicators varied at each site. The individuals at Town Creek Indian Mound (Mg2-3) and Fredricks (Or231) had few individuals with these indicators while Stockton (Vir 231) had multiple cases of metabolic disease indicators. With the ethnographic and archaeological research presented, it seems as if the cases of metabolic disease increased during the prehistoric period but decreased during the Contact period, which supports my hypothesis.

However, when the presence of metabolic disease indicators is broken down specifically into deficiency types, Town Creek (Mg2-3) actually had the highest proportion of individuals that appeared to be suffering from scurvy (Town Creek [Mg2-3] 23%, Stockton [Vir231] 10.5% and Fredricks [Or231] 10%). This breakdown contradicts the hypothesis and may indicate a lack of vitamin C rich foods, such as fruits and uncooked vegetables. However, only six individuals at all of the sites showed any evidence of scurvy, and the higher presence of vitamin C deficiency lesions at Town Creek (Mg2-3) may be associated with this small number or cultural differences. Further analysis of Piedmont sites would need to be conducted to determine if the results were skewed due to the small proportion of individuals with vitamin C deficiency lesions.

**Oral Health**

Based on the conclusions of other archaeological evidence, such as Lambert's 2000 study of North Carolina and Virginia, I also hypothesized that changes in the oral environment increased throughout the prehistoric periods and decreased during the Contact period due to diet. Over 76% of all of the individuals examined for this study had a least one cavity. The breakdown of the presence of cavities among the sites reveals interesting information that may contradict some of the evidence of metabolic disease previously discussed in this paper. In addition, similar to the comparative studies for metabolic diseases, the percentage of individuals affected by changes in oral health in this study was less then comparative Woodland sites except for the percentage of alveolar infection (Table 25). This higher percentage of alveolar infection in my study may be due to the small sample size of this study.

The changes in oral health of these three skeletal series may also be attributed to diet. Cavities are associated with diets heavy in sucrose because of the sugars' fermentation and effect on the teeth (Roberts and Manchester 2005, 65). The presence of dental carious lesions increased in time with the three sites. Town Creek (Mg2-3) had 75% of individuals with at least one cavity, Stockton had at least 76% of individuals with at least one cavity and Fredricks (Or231) had at least 80% of individuals with at least one cavity.

Larsen concluded in 1984 that an increase in sucrose in the diets of indigenous inhabitants of the Georgia Coast led to an increase in the number of cavities in male and females by about 10% (Roberts and Manchester 2005, 67). In addition, Larsen also concluded that there tended to be a 7% increase in the number of cavities when the populations switched to agriculture (Larsen 1997, 68). Alongside the high amount of sucrose in one's diet, there is also a positive correlation between the number of cavities and the age of an individual. Based on this study, there was a higher proportion of the skeletal series at Fredricks (Or231) that had cavities. In addition, the majority of the sample examined for Fredricks were either in the young adult or child age category (nine individuals). Based on the previous research, I would expect that Town Creek (Mg2-3) or Stockton (Vir231) would have higher proportions of individuals with dental carious lesions because they had an overall older sample then the young Fredricks (Or231) sample. This discrepancy may indicate a high maize or high sugar diet for the children of Fredricks. This idea is supported by ethnographic data that described how young children were often weaned from their mother's milk with grain gruel which often did not meet all of the nutritional requirements. This time period of weaning is often considered the most dangerous time for children and infants because there tends to be high mortality related to weaning (Katzenberg and Pfeiffer 1995, 221).

However, when examining the presence of cavities with the other indicators of changes in oral health examined for this paper (alveolar infection and ante-mortem tooth loss), the individuals at Stockton (Vir231) appear to have a much higher frequency, indicating poorer oral health than the other two sites. Twenty individuals in total at the three sites had at least two of the three changes in oral health examined for this paper. Five of these individuals were from Town Creek (Mg2-3) (25%), twelve were from Stockton (Vir231) (60%) and three were from Fredricks (Or231) (15%). Based on these results, the majority of the individuals examined from Stockton (Vir231) suffered from two indicators of poor oral health.

Similar results occurred when narrowing the number of individuals down to those with all three indicators of changes in the oral health environment. One individual from Town Creek (Mg2-3), eight individuals from Stockton (Vir231) and one individual from Fredricks (Or231) had evidence of all three indicators. By comparing the number of individuals with cavities in relation with the number of individuals with cavities and alveolar infections and ante mortem tooth loss, the skeletal series from Stockton (Vir231) appeared to have the worst oral health. The high frequency indicators of poor oral health would contradict the evidence of the high number of cavities seen at Fredricks and support the hypothesis that the overall health decreased during the prehistoric period but increased during the Contact period.

**General Health**

The other indicators of overall health examined for this study (periosteal reactions, osteomyelitis, enamel hypoplasias, and sinus infections) also reveal a lot about the overall health of the individuals at these three sites. The percentages of these indicators vary in comparison to the comparative studies (Table 25). There were higher percentages of periosteal reactions in this study than the comparative studies. However, there is only about 1% difference between my results and the comparative studies which may be attributed to sampling error. This sampling error may have been caused by the small sample size or random chance in the examination of the skeletal remains. In contrast, the difference between osteomyelitis was much higher. However, this discrepancy may be attributed to the researchers separating osteomyelitis from treponemal infection whereas in this study I grouped them together.

Skeletal indicators of osteomyelitis and sinusitis are evidence of an infection. Goodman, Martin, Armelagos and Clark have concluded that recent research, "has emphasized the synergistic interaction which infectious disease has with nutritional and degenerative disease. Often one pathophysiological state will predispose an individual to one or several other diseases" (Goodman, Martin, Armelagos and Clark 1984, 33). Based on the previous evidence for metabolic bone disease and oral health indicators, it could be predicted that there would be a higher proportion of individuals in Stockton (Vir231) with evidence of general stress indicators such as infectious diseases. Evidence of osteomyelitis was only found at Stockton (Vir231), which is consistent with the other two categories of health, metabolic and oral health, examined. One individual from Town Creek (Mg2-3), eight individuals from Stockton (Vir231) and one from Fredricks (Or231) had sinus infections, again supporting the evidence found in the previous two categories. Based on the synergistic relationship between infectious diseases and diet, it is evident that the high frequency of infectious diseases at Stockton (Vir231) supports the idea that the individuals there were overly reliant on maize agriculture thus not allowing the individuals to have an adequate diet of the proper nutrients needed.

The final two indicators of general health, periosteal reactions and enamel hypoplasias, also reveal information about the overall health of individuals from the Piedmont. Four individuals from Town Creek (Mg2-3), twelve individuals from Stockton (Vir231) had evidence of periosteal reactions with only one individual from Fredricks

(Or231) showing signs of periosteal reactions. In contrast, only four individuals, one from Town Creek (Mg2-3), none from Stockton (Vir231), and three from Fredricks (Or231), showed evidence of enamel hypoplasias.

The higher number of individuals at Fredricks with enamel hypoplasias, like the dental caries, contradict my hypothesis about health increasing during the Contact period because enamel hypoplasias are often indicators of poor health. However, there are multiple causes of enamel hypoplasias such as genetic abnormalities or trauma (as described in Chapter 2), which could have effected the development of the teeth. Although the evidence for enamel hypoplasias was contradictory, the sample size of individuals with hypoplasias was so small that the results may have been skewed. In addition, the percent of individuals affected by enamel hypoplasias was less then those in the comparative studies which could also indicate a sampling error.

In conclusion, it is evident that there were mixed results when it came to the health of the individuals from the Piedmont. The individuals examined from Stockton (Vir231) appear to have the highest number of indicators of health in all three overall categories: metabolic health, dental health, and general health. This high proportion of individuals at Stockton (Vir231) suffering from these changes in health could indicate an overreliance of maize agriculture in the diet. Because maize lacks several important nutrients, the overreliance of this crop could have led to the poor health of these individuals. However, the botanical and faunal samples taken from two of these sites have not been analyzed yet, so many of these conclusions drawn about diet and nutrition in this paper are generalizations configured from similar related sites which could have skewed the results. Comparing the results of this study to the future botanical and faunal remains from Town Creek (Mg2-3), Stockton (Vir231), and

Fredricks (Or231) when they becoming available will provide a more accurate picture of health in the Piedmont of North Carolina and Virginia during these time periods and allow more conclusions about diet and nutrition to be made about these three sites. In addition, the differences in the percentage of individuals affected in my study versus the comparative studies may be attributed to the small sample size of this study as well as the poor preservation of some of the skeletal remains.

A breakdown of the three categories by specific indicators demonstrated that other sites had higher numbers of individuals with health problems. For example, Fredricks had a higher proportion of individuals suffering from cavities than Stockton. Lambert in her study of the Piedmont concluded that, "variation within this region further suggest that variables such as resource distribution, quality of arable land, microclimatic variability, and unique cultural practices influenced health and thus the quality of life in various regions of North Carolina and Virginia" (Lambert 2000, 192). Due to the inconclusive nature of the results of this study, it appears that these variables did play a role in the overall health of individuals interred at these three sites. Further studies of skeletal series from the Piedmont will undoubtedly contribute information that can be used in order for a more reveal accurate picture of the overall health and lifestyles of these indigenous peoples due to their foodways.

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Appendix I

Individuals with Cavities

| Site | Individual | Age Category | Sex | Teeth Affected |
|---|---|---|---|---|
| Mg2-3 | 1B | Mature Adult | Male | Left max. pm3,m2,m3 right max. pm3,m1, left mand. C,pm3,pm4,m1,m2,m3, right mand. M1,m3 |
| Mg2-3 | 7 | Child | n/a | Right max. deciduous m2 |
| Mg2-3 | 31 | Adolescents | n/a | Right max. m2, left mand. C right mand. M1 deciduous m1 |
| Mg2-3 | 8 | Mature Adult | Female | Left max. I1,I2,m1,m2, right max. I1,m1 left mand. I2,c, right mand I2, c,pm3 |
| Mg2-3 | 36 | Mature Adult | Female | Left max pm4, right max m1,m2 |
| Mg2-3 | 5 | Adolescents | n/a | Left max m1, right max, m2,m3 left mand. M3, righ tmand. M1,m2 |
| Mg2-3 | 29 | Mature Adult | n/a | Left max. I1,c,m1,m2.m3, right max. pm3.pm4,m1,m2,m3 left mand. C, pm4,m1,m2,m3, right mand. Pm3,pm4, m1,m2,m3 |
| Mg2-3 | 30 | Young Adult | n/a | Left max. I2,m3, right max. I1,c, left mand. C, pm3, m3 |
| Mg2-3 | 41 | Young Adult | Female | Left max. I1, m1,m2,m3, right max. I1,m1,m3 left mand. Pm4 |
| Vir231 | 4 | Young Adult | Female | Left mand. I1, right mand. Pm3 |
| Vir231 | 5 | Young Adult | Female | n/a |
| Vir231 | 6 | Mature Adult | n/a | Left max. I2, right max. pm3,pm4, right mand. I2,m1,m2,m3 |
| Vir231 | 8 | Older Adult | Male | Left max. I1,I2c,pm3,pm4, right max I1,I2,c,pm3,pm4,m1,m2,m3, mand. I1,c,o3,pm4,m1,m2,m3 |
| Vir231 | 9 | Young Adult | Female | Left max I2,pm4,m1,m2,m3 right max I2,m3 left mand. |

| | | | | |
|---|---|---|---|---|
| | | | | Pm4,m2 right mand.pm4,m1,m2,m3 |
| Vir231 | 3 | Older Adult | Female | n/a |
| Vir231 | 13 | Mature Adult | Female | Left max I2,c,m2, right max I1,c,pm4,m1,m2,m3, left mandible I1,I2,c,pm3,pm4, right mandible I1,I2,c,pm3,pm4 |
| Vir231 | 14 | Mature Adult | Female | Left max. I2,c,pm4,m1,m3 right max. I2,Cpm3, Left mand. I1,I2,c, m3, Right mand. I1,I2,c,pm3,pm4,m3 |
| Vir231 | 15 | Mature Adult | Male | Left max. pm3,m1,m2,m3 right max. pm3,pm4,m2 right mand. C,pm3,m3 |
| Vir231 | 17 | Young Adult | Female | Max left pm3,pm4,m1, right max. I2,c,pm3, left mand. I1,I2,c,pm3,pm4,m1,m2,m3, right mand. I1,I2,c,pm3,m1,m2,m3 |
| Vir231 | 18 | Mature adult | Female | Left max. I2,C,pm3,pm4,m1, right max. I2,c,pm3,m2,m3 left mand. I2,c,pm3,pm4 |
| Vir231 | 20 | Mature Adult | Male | Left max. I1,I2,C,pm3,pm4,m1, right max. I1,I2,m1,m2,m3 |
| Vir231 | 21 | Mature Adult | Male | Left max. I1,I2,c,pm3,pm4,m1,m2,m3, right max. I1,I2,c,pm3,,m1,m2,m3, Left mand. I1,I2,c,pm3,pm4,m3, right mand. I1,I2,c,pm3,pm4,m3 |
| Or231 | 1 | Child | n/a | Left and max deciduous all teeth right mand. Deciduous i1,i2,m2, right mand. Deciduous i1,i2,m2 |
| Or231 | 2 | Child | n/a | Left max deciduous m1,m2 right max. deciduous c, m1,m2 left mand. Deciduous c right mand. Deciduous m1,m2 |
| Or231 | 3 | Young adult | Male | Left max. I1,I2,c,pm3,m1,m2,m3 right |

| | | | | |
|---|---|---|---|---|
| | | | | max all teeth, all teeth in mandible |
| Or231 | 4 | Mature Adult | Female | Left max. I1,I2,c,m1,m2,m3 right max. all teeth, left mand.all teeth, right mand. I2,pm3,pm4,m1,m2,m3 |
| Or231 | 5 | Young Adult | Female | Left mand I2,c,pm3 right mand c, pm3,pm4 |
| Or231 | 8 | Child | n/a | Left max deciduous i1,i2,c,m1, right max deciduous c,m1,m2 left mand. Deciduous c, m2 right mand. Deciduous i1,i2,c,m1,m2 |
| Or231 | 13 | Mature Adult | n/a | Left max. I2,c,pm3,pm4,m2 right max I2,c,pm3,pm4,m1,m2,m3 left mand. Pm3,pm4,m2,m3 right mand. C,pm3,pm4,m1,m2,m3 |
| Or231 | 11 | Young Adult | n/a | Left max (all teeth) right max. I1,I2,c,pm3,m1 left mand. I1,I2,c,pm3, m1,m2 right mand. I1,c,pm3,pm4,m1,m2 |

Appendix II

Additional Individual Information from Town Creek Indian Mound (Mg2-3)

| Site | Individual | Age | Sex | Health Problems |
|---|---|---|---|---|
| Mg2-3 | 1A | n/a | n/a | None |
| Mg2-3 | 1B | 31+ | Male | Cavities, alveolar infection, periosteal reaction |
| Mg2-3 | 41 | n/a | Female | Cavities, |
| Mg2-3 | 6 | 4-5 | n/a | Cavities, tooth loss, periosteal reaction, |
| Mg2-3 | 7 | n/a | n/a | n/a |
| Mg2-3 | 8 | 28+ | Female | Cavities, tooth loss, periosteal reaction, |
| Mg2-3 | 36 | 25-29 | Female | Cavities, alveolar infection, scurvy, |
| Mg2-3 | 37 | n/a | n/a | n/a |
| Mg2-3 | 10 | 1 | n/a | Scurvy, |
| Mg2-3 | 4 | n/a | n/a | scurvy |
| Mg2-3 | 5 | 12-16 | n/a | Cavities, porotic hyperostosis |
| Mg2-3 | 31 | 8-9 | n/a | Cavities, periosteal reaction, |
| Mg2-3 | 27 | mid 20s | Female | Alveolar infection, tooth loss, |
| Mg2-3 | 28 | n/a | n/a | n/a |
| Mg2-3 | 29 | 25+ | n/a | Enamel hypoplasia |
| Mg2-3 | 30 | n/a | n/a | cavities |

Individuals from Stockton (Vir231)

| Site | Individual | Age | Sex | Health Problem |
|---|---|---|---|---|
| Vir231 | 1 | 20-24 | | Alveolar infection, tooth loss, porotic hyperostosis, sinus infection |
| Vir231 | 3 | 38.2 ±10.9 | Female | Cavities, alveolar infection, tooth loss, porotic hyperostosis, sinus infection |
| Vir231 | 4 | 23+ | Female | Cavity, periosteal reaction, |
| Vir231 | 5 | 20 | Female | Cavities, alveolar infection, tooth loss, porotic hyperostosis, |
| Vir231 | 7 | 1±4months | n/a | scurvy |
| Vir231 | 6 | Less then 30 | n/a | Cavities, alveolar infection, tooth loss, periosteal reaction, sinus infection |
| Vir231 | 8 | mid 30s | Male | Cavities, alveolar infection, tooth loss, porotic hyperostosis, scurvy, periosteal reaction, osteomyelitis, sinus infection |
| Vir231 | 9 | 20-24 | Female | Cavities, alveolar infection, periosteal reaction, osteomyelitis, sinus infection |

| | | | | |
|---|---|---|---|---|
| Vir231 | 10 | 20 | n/a | Sinus infection |
| Vir231 | 11 | 2±4months | n/a | Cribra orbitalia, periosteal reaction, |
| Vir231 | 13 | 24-32 | Female | Cavities, alveolar infection, tooth loss, porotic hyperostosis, osteomyelitis, |
| Vir231 | 14 | 30+ | Female | Cavities, alveolar infection, tooth loss, periosteal reaction, |
| Vir231 | 15 | 24-28 | Male | Cavities, alveolar infection, tooth loss, periosteal reaction, osteomyelitis, sinus infection |
| Vir231 | 16 | n/a | n/a | n/a |
| Vir231 | 17 | 20-24 | Female | Cavities, periosteal reaction, |
| Vir231 | 18 | 25 | Female | Cavities, alveolar infection, tooth loss, periosteal reaction, |
| Vir231 | 19 | 1±4 months | n/a | n/a |
| Vir231 | 20 | 25-28 | Male | Cavities, tooth loss, periosteal reaction, |
| Vir231 | 21 | 25-29 | Male | Cavities, alveolar infection, tooth loss, periosteal reaction, |
| Vir231 | X | 21-24 | Female | Tooth loss, periosteal reaction, |
| Vir231 | 22 | Age of birth | n/a | Alveolar infection, cribra |

| | | | | |
|---|---|---|---|---|
| | | | | orbitalia, sinus infection |
| Vir231 | No number | 0-3 | n/a | n/a |

Individuals from Fredricks (Or231)

| Site | Individual | Age | Sex | Health Problems |
|---|---|---|---|---|
| Or231 | 1 | 4±1 | n/a | Cavities, |
| Or231 | 2 | 8±2 | n/a | Cavities, scurvy, enamel hypoplasia |
| Or231 | 3 | 20-24 | Male | Cavities, alveolar infection, porotic hyperostosis, |
| Or231 | 5 | 22-24 | Male | Cavities, alveolar infection, tooth loss, sinus infection |
| Or231 | 4 | 30+ | Female | Cavities, alveolar infection, periosteal reaction, |
| Or231 | 4a | n/a | n/a | n/a |
| Or231 | 6 | n/a | n/a | Enamel hypoplasia |
| Or231 | 7 | n/a | n/a | n/a |
| Or231 | 8 | 4±1 | n/a | cavities |
| Or231 | 13 | 25-29 | n/a | Cavities |
| Or231 | 11 | 15±3 | n/a | Cavities, enamel hypoplasia |

Appendix III

Selected Glossary (White and Folkens 2005, 419-426)

**Abscess**: a localized collection of pus in a cavity formed by the tissue disintegration; often found as cavities within alveolar bone near the tooth root apices

**Ameloblasts**: cells that form enamel through a process known as amelogenesis

**Antemortem**: before time of death

**Attrition**: wear, usually used in reference to teeth

**Calculus**: tartar, a deposit of calcified dental plaque on teeth

**Caries**: a disease characterized by the progressive decalcification of enamel or dentine; the hole or cavity left by such decay

**Cementum**: A bone-like tissue that covers the external surface of tooth roots, surrounding the dentin of the root and neck of a tooth

**Collagen**: A fibrous structural protein constituting about 90% of bone's organic content

**Commingled**: Bone assemblages containing remains of multiple individuals, often incomplete and fragmentary

**Congenital**: acquired during development in the uterus, not through heredity

**Enamel**: a layer of extremely hard, brittle material that covers the crown of a tooth

**Lesion**: an injury or wound; an area of pathologically altered tissue

**Necrosis**: physiological death of a cell or a group of cells

**Osteoblasts**: The bone-forming cells responsible for synthesizing and depositing bone material

**Osteoclasts**: Cell responsible for the resorption of bone tissue

**Periosteum**: Thin tissue covering the outer surface of bones except in areas of articulation

**Radiograph**: an image produced on photographic film when exposed to X-rays passing through an object

**Remodeling**: A cyclical process of bone resorption and deposition at one site

**Resorption**: The process of bone destruction by osteoclasts

**Sagittal suture**: the midline suture that passes between the parietal bones

**Sinuses**: Void chambers in the cranial bones that enlarge with the growth of the face; four basic sets, one each in the maxillae, frontal, ethmoid, and sphenoid

**Symphysis**: A type of cartilaginous joint in which fibrocartilage between he bone surfaces is covered by a thin layer of hyaline cartilage