1-1-2000

Skeletal evidence of tuberculosis and treponematosis in a prehistoric population from west-central Illinois

Angela Jo Hanson
Iowa State University

Follow this and additional works at: https://lib.dr.iastate.edu/rtd

Recommended Citation
Hanson, Angela Jo, 'Skeletal evidence of tuberculosis and treponematosis in a prehistoric population from west-central Illinois' (2000). Retrospective Theses and Dissertations. 17902.
https://lib.dr.iastate.edu/rtd/17902

This Thesis is brought to you for free and open access by the Iowa State University Capstones, Theses and Dissertations at Iowa State University Digital Repository. It has been accepted for inclusion in Retrospective Theses and Dissertations by an authorized administrator of Iowa State University Digital Repository. For more information, please contact digirep@iastate.edu.
Skeletal evidence of tuberculosis and treponematosis in a prehistoric population from west-central Illinois

by

Angela Jo Hanson

A thesis submitted to the graduate faculty in partial fulfillment of the requirements for the degree of

MASTER OF ARTS

Major: Anthropology

Major Professor: Dawnie Wolfe Steadman

Iowa State University

Ames, Iowa

2000

Copyright © Angela Jo Hanson, 2000. All rights reserved.
This is to certify that the Master’s thesis of

Angela Jo Hanson

has met the thesis requirements of Iowa State University

Signatures have been redacted for privacy
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACKNOWLEDGEMENTS</td>
</tr>
<tr>
<td>CHAPTER ONE.</td>
</tr>
<tr>
<td>CHAPTER TWO.</td>
</tr>
<tr>
<td>CHAPTER THREE.</td>
</tr>
<tr>
<td>CHAPTER FOUR.</td>
</tr>
<tr>
<td>CHAPTER FIVE.</td>
</tr>
<tr>
<td>CHAPTER SIX.</td>
</tr>
<tr>
<td>CHAPTER SEVEN.</td>
</tr>
<tr>
<td>APPENDIX 1:</td>
</tr>
<tr>
<td>REFERENCES CITED</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

This thesis has been a very large part of my life for the past couple of years and I fear that I would not have succeeded if not for the help of several individuals mentioned below.

First, I would like to thank the ISU Department of Anthropology for the summer research assistantship that allowed me to complete my master's research. Also, thanks go to Dan and the staff at Mary Greeley Medical Center Radiology Department for taking the radiographs mentioned in this study. Thank you to John Dorn of N8 Digital for providing the beautiful illustrations presented in chapter 3.

Next, I owe a great deal of thanks to my master's committee: Dr. Michael Whiteford (ISU Department of Anthropology), Dr. Jeffrey Beetham, and Dr. Charles Thoen (both at ISU College of Veterinary Medicine). Each has made his own contribution to see this thesis to completion. Dr. Whiteford was a reliable source of support and was always willing to answer anything thesis-related. Dr. Beetham was particularly helpful in making this project a valid and potentially publishable work. Finally, Dr. Thoen consistently showed a tremendous amount of enthusiasm for this project.

I would like to recognize the head of my committee, Dr. Dawnie Wolfe Steadman (formerly of ISU, now at State University of New York-Binghamton). When I first approached her a couple of years ago about going into “forensic anthropology,” I had no idea of the broad scope of physical anthropology. This work is in part a realization of that ideal. She has constantly been a driving force in my growth as a graduate student and always pushed me to do better, even when I felt I could not.

I would like to thank Dr. Della Cook of Indiana University, Bloomington, for graciously allowing me time in her lab to examine some of the pathological cases in the
Schild sample. In addition, she provided a great deal of assistance in diagnosing potential cases in Orendorf. Dr. Jane Buikstra of the University of New Mexico was a wonderful source of information in regards to paleopathological research, especially that dealing with TB. I would like to thank Larry Conrad of Western Illinois University for his hospitality during my visits and for providing me with work space there. Also, Dr. Radford Davis (ISU College of Veterinary Medicine) was very helpful in explaining epidemiological formulas and their potential applicability to paleopathology. Finally, Dr. Fred Lorenz (ISU Department of Statistics) and Robb Nielsen kindly helped me with the statistics in this study.

I have so many friends that have supported me throughout the past years that to name them all would take up too much space. However, a few warrant special mention. I would like to say thank you to Jen Rediske for everything from long runs in the freezing cold, to pig-out sessions at Hickory Park, to marathon conversations about anything. Her support has meant a great deal to me. I would also like to thank my long time friend Heather Campbell; while our lives have taken separate paths since our days at Grand View College, her belief in me has never wavered. I would also like to recognize my boss and friend, Sherri Howerton. She has been a wonderful source of support and has allowed me to plug away at my “mini-manifesto” while I was working. In addition, my “Wessex friends” (i.e. Barry, Russ) deserve a note of thanks; they listened to me talk constantly about my thesis and still remained my friends…they also showed me that being a graduate student and having a good time were not mutually exclusive entities.

I would also like to thank all of the anthropology graduate students whose paths I have crossed during my time at ISU. Each of you has a special place in my heart. To Cam
Walker, thanks for being such a wonderful friend and my long-distance source for moral support as well as laughs.

A very big thank you goes to my family. I owe a significant debt of gratitude to my parents, Ed and Janet Palmer, who have never given up on me, in both the good times and the bad. Their constant pride and belief in me has sometimes been the only thing that has kept me going when things got really tough. Thanks to my brother and sister, Jeremy and Amanda Palmer, who have always been a silent source of support and have yet to figure out what their big sister wants to be when she grows up. A special thanks goes to my sister for introducing me to the “only music that I can write to.” My “parents-in-law,” Lyle and Virginia Hanson, also deserve recognition. They have listened to me complain a time or two when it appeared that the end was never in sight. To my sister-in-law, Liz Hanson, thank you for your cards and emails that truly served as “pick me ups” on more than one occasion.

To my husband, Jason, I owe the biggest thank you. His never-ending love and faith have gotten me through many other things in addition to this project. Many evenings he patiently occupied himself while I sat at my computer, headphones on, oblivious to all around me. I know in my heart that I will never be able to repay him for all that he has sacrificed and put up with for the last 2 ½ years.
CHAPTER ONE
INTRODUCTION

The goal of paleopathological research is to examine the skeletal remains of previous populations and use the data to generate hypotheses about the health and welfare of these individuals. Examples of conditions that can tell a substantial amount about past health are osteoarthritis, cribra orbitalia, porotic hyperostosis, tuberculosis (TB) and treponematosis. Data from these studies have the potential to provide a wealth of insight into the adaptation, culture, and disease patterns of previous human populations (El-Najjar 1979).

The focus of the current research is to assess the frequency of TB and treponematosis in the Orendorf Mississippian sample, a prehistoric population who inhabited the central Illinois valley from approximately A.D. 1150 to 1250 (Conrad 1991; Harn 1991). Based on various cultural and demographic parameters gleaned from the archaeological record, the hypothesis that this representation of the Orendorf population will manifest skeletal evidence of TB and treponematosis is tested. The central issue of this investigation is to better understand the frequency of TB and treponematosis in a pre-Columbian population through the use of basic epidemiological principles and a biocultural perspective.

There are two aspects of Mississippian populations that make them particularly vulnerable to infectious disease. The first is the rise of an agriculturally based subsistence strategy built primarily around the cultivation of maize; the second is the presence of intricate and complex trade networks that allow for more contact between distant populations e.g. (Lallo and Rose 1979). Maize agriculture is thought to contribute to an overall increase in the size (Griffin 1967) and density (Goodman, et al. 1984; Lallo and Rose 1979) of Mississippian populations. Sedentism is often correlated with population growth; in tandem,
the two have been discussed as key factors in the survival and transmission of various infectious pathogens (Goodman, et al. 1984; Lallo and Rose 1979). A number of sites throughout prehistoric North America, such as Dickson Mounds and Schild sites in the American Midwest and Moundville in the Southeast, have archaeological evidence of maize agriculture. Therefore, it can be assumed that population growth and sedentism were probable outcomes at these sites (Buikstra 1976a; Buikstra and Cook 1981; Goldstein 1980; Lallo 1973; Lallo and Rose 1979; Powell 1988).

It has been postulated that Mississippian groups traded with one another as evidenced by a number of exotic trade items unearthed at various sites in which they were likely not created. For example, Dickson Mounds (Lallo 1973; Lallo and Rose 1979) and the Schild sites (Goldstein 1980), as well as Moundville (Powell 1988), all possessed non-locally manufactured artifacts. The actual act of trading allows an opportunity for increased person-to-person contact between different groups. Further, some authors suggest that more external contacts outside the group provides for a potential increase in the frequency of infectious diseases manifested within populations (Goodman, et al. 1984; Lallo and Rose 1979; Manchester 1984). Tuberculosis is passed between persons via inhalation e.g. (Wolinsky 1994), while treponematosis can be transmitted either sexually, congenitally, or by skin-to-skin contact (Hackett 1967), methods that could have allowed for effortless dissemination throughout and between Mississippian populations. Therefore, it can be assumed that when Mississippian individuals participated in trade activities, they were not just exchanging material objects, but pathogens as well.

The Orendorf site was occupied between approximately A.D. 1150-1250 and is classified in the Mississippian cultural tradition (Conrad 1991). Therefore, this society is
present prior to European contact and is considered pre-Columbian. Typical of Mississippian
societies, maize agriculture was practiced at Orendorf: as evidenced by the remains of maize
in flotation analyses of soil excavated within features at the site (Conrad 1991; Good 1981).
This indication of maize agriculture, in addition to archaeological evidence of
semisubterranean, permanent house structures and long-term site occupation (Conrad 1991)
imply that Orendorf might have experienced some population growth and that the individuals
occupying the site were more sedentary than previous hunter-gatherers in the region. Also, it
is likely that Orendorf participated in some form of a trade network, due to the presence of
faraway objects, such as marine shell artifacts from Florida; effigy water bottles and marine
shell dippers from the Central Mississippi Valley; and chert from other regions in Illinois
(Conrad 1991).

When considering that Orendorf possessed those factors necessary to exhibit TB and
treponematosis (maize agriculture, moderate population size and sedentism, trade
networking), a hypothesis can be created in regards to the possible manifestation of these
diseases in this particular group. Further, a number of researchers have examined the skeletal
remains of individuals occupying other Mississippian sites, such as Dickson Mounds, Schild,
and Moundville, and have found evidence of TB and treponematosis-like lesions (Buikstra
1976a; Buikstra and Cook 1981; Goodman, et al. 1984; Lallo 1973; Powell 1988; Powell
1991). These societies possess comparable cultural characteristics as Orendorf (namely
maize agriculture, similar settlement patterns, and trade); these characteristics, coupled with
the evidence of TB and treponematosis-like lesions at these sites, further corroborate the
suggestion that Orendorf should have the potential to support these diseases. Therefore, it is
hypothesized that these individuals will show evidence of both TB and treponematosis in their skeletal remains.

The presence or absence of these diseases will be determined through a direct macroscopic examination of the skeletal remains of the Orendorf population. Skeletal changes considered diagnostic of TB or treponematosis are thoroughly documented and radiographed. For instance, TB is characterized by osteolytic lesions of the spine and synovial joints with little proliferative reactions so all lytic lesions in these areas are described. The responsible disease process is determined through the use of differential diagnosis, i.e. conditions that resemble TB and treponematosis are eliminated based upon factors such as specific diagnostic features, cultural practices, demographics, and geography (Aufderheide and Rodriguez-Martin 1998; Buikstra 1976a; Buikstra and Cook 1981). Specific diagnostic features used to eliminate questionable lesions include the location (i.e. which skeletal element is affected), type (lytic or formative), and the presence or absence of healing processes.

After the examination of the skeletal remains, it is discovered that some individuals demonstrate pathological changes that are similar to those expected for TB and treponematosis. These individuals are then put into one of two categories according to the type of lesions that they possess: possible and likely. Possible lesions are those that have skeletal changes that are suggestive of the diseases, but are still ambiguous enough to prevent further classification into the likely category. Lesions labeled as likely are those that probably fulfill the diagnostic criteria of TB and treponematosis. Differential diagnosis is then applied in order to determine the responsible pathology for these suspicious lesions. It is subsequently determined that there are 2 possible cases of TB, 4 possible cases of
treponematosis, 1 likely case of TB and 3 likely cases of treponematosis. When comparing these numbers to other prehistoric sites with evidence of the diseases, it is further concluded that there really are not any significant differences between Orendorf and other Mississippian populations in the number of individuals with TB and treponematosis. However, when comparing the number of those with TB between Orendorf and Norris Farms #36, a later Oneota site, a significant difference is found.

Examination of ancient remains is the only method in which paleopathologists can comprehend and interpret the health of past individuals. Much can be learned about the lifestyle of these people as well as the various biological stresses and challenges that they may have faced. Further, paleopathological research can explain how humans and pathogens have coevolved and adapted to one another. As a result, we can potentially garner a clearer picture of modern health and response to disease. The results of the current investigation may also be useful for future investigations into paleoepidemiology. Orendorf is a fitting population to use for this type of study. First, it has not previously been subject to a systematic study of infectious disease. Second, it is one of few relatively large prehistoric samples still available for study and would provide appropriate comparisons to similar work done on other Mississippian and non-Mississippian groups. Finally, there is great potential for multidisciplinary collaboration in epidemiological modeling, such as the determination of risk for infectious disease, for which Orendorf could be an excellent candidate.
CHAPTER TWO
MISSISSIPPIAN CULTURE AND THE ORENDOF POPULATION

The Mississippian culture (A.D. 900-1600) is a cultural tradition that was widespread throughout a large portion of the central and southeastern regions of the United States. This tradition is considered to be relatively complicated with multiple characteristics distinguishing it from earlier cultures. It is believed to have originated in the central Mississippi valley by A.D. 1000 (Goldstein 1980) and dispersed throughout the region and into portions of the southeastern United States by the eleventh century (Muller 1997). The representation of material culture at Mississippian sites is fairly similar in regards to the types of artifacts exhibited. However, it is the intersite variability demonstrated in the patterns, styles, of such artifacts that contribute to this period’s immense complexity (Goldstein 1980). Differences in site location and social organization, subsistence practices, mortuary practices, and artifact forms make Mississippian culture distinct from earlier Woodland populations.

Mississippian Sites and Social Organization

The location of Mississippian sites likely played a decisive role in the success of this cultural tradition. As will be discussed in more detail later, Mississippian societies were largely dependent upon agriculture for subsistence. Therefore, it was advantageous to place sites in areas where crops were most likely to flourish. Sites were normally situated near major waterways (i.e. rivers and streams) in fertile floodplains that supplied easily worked, nutrient-rich soils e.g. (Goldstein 1980; Griffin 1967; Smith 1978). The soil types located in the bottom lands near large waterways provided ideal conditions for rearing the various crops that Mississippians were dependent upon (Griffin 1967: 189).
The structure of Mississippian communities is much more complex than its cultural predecessors of the Woodland tradition. Subsistence practices dictated that societies be more permanent, in contrast to hunter-gatherers of the past, whose settlements were much more mobile. Mississippian communities were intricate arrangements of large urban areas, towns, villages, and farmsteads whose layout is somewhat analogous to concentric circles (Goldstein 1980). At the core of these settlements were major urban centers that contained temple mounds and a plaza (Goldstein 1980; Milner 1998). These urban centers were the residences of various leaders of the society; in fact, the mounds served as foundations for a number of large buildings (i.e. council houses, temples, charnel houses) that held sociopolitical importance (Griffin 1967; Milner 1998). At Cahokia, for example, the platform mounds were likely the locale for important public buildings as well as high-status residences; the conical mounds probably held the charnel house and possessed other mortuary functions (Fowler 1978). Beyond the urban centers were smaller towns that may have had a few mounds and possibly a plaza; the furthest limits of Mississippian societies consisted of scattered villages and farmsteads in which no mounds or ornate architecture were present (Goldstein 1980). Fowler (1978) designates this organizational system as first through fourth-line communities, with the major urban center at Cahokia being the only first-line community that exhibited much influence on those outlying centers. However, this model has been subject to much criticism, with many authors providing archaeological evidence that suggests a different organizational scheme to Mississippian settlement patterns e.g. (Milner 1990; Milner 1991).

Mississippian people were also organizing their societies in a manner not displayed by earlier peoples. In Mississippian communities, social organization appeared to be more
structured, that is, egalitarian frameworks were replaced by hierarchies where social
delineation was the norm (Kelly 1990b; Milner 1998). There was an emergence of an elite
class within the society, with more influence being exerted from the upper echelon down to
the lower levels (Muller 1997). Thus, Mississippian communities are often referred to as
chiefdoms (Milner 1998; Muller 1997). According to Milner, chiefdoms are defined as
“...societies with minimal economic specialization, ranked and kin-based social groups, a
limited number of inherited leadership positions, and chiefs who possess great prestige but
little true power” (1998:2). This type of ranked society likely served a couple of purposes.
First, it appears that the upper crust of Mississippian societies controlled access to resources
and hence, had redistribution power to their subordinates (Milner 1998). However, Muller
(1997) feels that the presence of redistribution in Mississippian groups may be misconstrued,
based upon what he believes is a lack of evidence for such activity. According to him,
redistribution may have been practiced only in the realm of “ceremonial” functions and not
for the purposes of everyday survival (1997:360-361).

Another purpose of chiefdoms is to control the immense amount of labor required to
construct elaborate structures, such as mounds. Those in elitist positions must be able to
assemble their followers in order to be successful on such projects. Sometimes, much
manpower and organization is of utmost importance, especially in the construction and
maintenance of magnificent architecture, such as Monk’s Mound and “Woodhenge” at
Cahokia (Milner 1998; Young and Fowler 2000).
Mortuary Practices

The social organization of Mississippian societies is also reflected in the treatment of the deceased. As with other facets of Mississippian culture, mortuary customs were intricate and complex (Goldstein 1980; Milner 1998). It appears that those of higher social standing were given preferential treatment not only in the location of their graves and burial activities, but in their grave goods as well. For example, in the American Bottom near Cahokia, those of sociopolitical importance were interred in large burial mounds, with a variety of elaborate artifacts accompanying them. These artifacts include: marine shell beads, carefully crafted arrowheads, and other items made with exotic materials, such as copper and mica. In the actual graves, remains from several individuals were often buried together as bundles of disarticulated bones that were strategically arranged. This sort of technique is believed to have emphasized the focus on the group, rather than the individual (Milner 1998).

On the other hand, those on the lower spectrum of Mississippian society were given a much different treatment at death that those of higher rank. Usually these “common” forms of burial were seen at outlying communities, away from the larger, more urban populations (Goldstein 1980). Mounds were still used as locations of interment, but were smaller than those used for the elite class. Also, individuals were more often buried in fully articulated flexed, semiflexed, and extended manners, but disarticulated bundle burials still occurred (Goldstein 1980; Milner 1998). Grave furniture was much less elaborate, as these people were often buried with common items, such as pottery and tool kits, with little evidence of exotic trade items (Milner 1998).
Subsistence Practices

One of the defining characteristics of Mississippian culture is the dramatic shift in dependence from foraging to agriculture. As previously stated, Mississippian sites were situated near rivers and floodplains where crops could have the best opportunity to thrive. The most important staple crop appears to be maize, although others, such as beans and squash, were cultivated as well (Fowler 1978; Goldstein 1980; Griffin 1967; Muller 1997). Also, exploitation of local fauna was still evident, with hunting and fishing continuing as important methods of food procurement, but likely on a much smaller scale than before (Goldstein 1980; Muller 1997). While it is important to note the presence of additional crops and game in the Mississippian diet, a great deal of research is devoted to understanding the impact of maize agriculture.

Archaeological evidence of maize agriculture at Mississippian sites can occur on three levels: artifacts, floral analysis, and isotope studies. For example, artifacts such as shell and chert hoes were unearthed at Dickson Mounds, a Mississippian site located in the central Illinois valley (Harn 1980). Stone and shell hoes were also excavated at Cahokia, a major Mississippian site near present day St. Louis (Milner 1998). It can be assumed that artifacts of this type were of major importance in the cultivation of maize and other crops. Also, the remains of storage pits that may have been used for storing food were excavated at Cahokia (Milner 1998) and the Myer site, near Dickson Mounds (Harn 1980), as well as Dickson Mounds (Lallo and Rose 1979).

The remains of maize and other plants have also been discovered at a number of Mississippian sites. Through flotation analysis, Johannessen (1984) has recovered evidence of maize from six sites in the American Bottom region (Carbon Dioxide, Lohmann, Motor,
Range, Julien, and Turner). Maize remains have also been found at Moundville in the southeast United States (Powell 1988) and the Larson site in the central Illinois River valley (Conrad 1991).

Isotope studies provide some of the most compelling evidence for the presence of maize in the diet of Mississippian peoples. The main isotope of interest in reference to maize agriculture is carbon-13; this isotope is known to increase when an organism ingests C4 plants, such as maize, in high amounts (Buikstra 1992; Buikstra, et al. 1988). A number of bioarchaeological studies have utilized carbon isotope analysis to determine not only the presence of maize in the subsistence patterns of prehistoric populations, but also to trace its development as the primary dietary component of Mississippian societies e.g. (Buikstra 1992).

While the shift to agriculture provided a more stable food source for Mississippian peoples, it was not without consequence. These ramifications cover both the social and biological spectrums, and appear to be intricately linked, as will be explained shortly. The first of these consequences is the effect that agriculture had on those populations in which it was practiced. Worldwide, it seems that the adoption of agriculture had a profound impact on population size, in that it increased with the adoption of this subsistence practice (Larsen 1995). The same result is manifested in Mississippian societies, with populations growing larger with the adoption of maize cultivation (Griffin 1967). In addition to greater population numbers, agriculture allowed for a reduction in group mobility and an increase in sedentism; hence, individuals were occupying more permanent settlements and congregating closer together because this subsistence practice dictated that people remain near their crops (Cockburn 1971). This shift to a more settled lifestyle and subsequent increase in population
density is believed to have taken place in Mississippian groups, such as Dickson Mounds (Goodman, et al. 1984; Lallo and Rose 1979).

The biological ramifications of these changes in population structure have been addressed at length throughout paleopathological literature. It is very difficult for microbes to survive in smaller groups where the availability of susceptible hosts is more limited than in larger groups (Cockburn 1971). Sedentary conditions coupled with the increased size of agricultural societies provide an ideal environment for the transmission and perpetuation of infectious pathogens in these populations (Cockburn 1963; Cockburn 1971; Goodman, et al. 1984; Larsen 1995). In addition, a decrease in community hygiene resulting from poorer living circumstances often accompanied sedentism and can contribute to an increase in infectious disease in agriculturalists (Larsen 1995). A number of Mississippian groups are believed to show an increase in infectious disease over their Woodland predecessors. For example, Buikstra and Cook (1981) discovered the emergence of TB-like lesions in the Mississippian component of the Schild population from the Lower Illinois valley. Also, remains from the Dickson Mounds site are purported to have a higher overall rate of infectious disease that is felt to be partially the result of increased sedentism (Goodman, et al. 1984; Lallo 1973; Lallo and Rose 1979).

Artifact Forms

It is important to note that in an archaeological context the term “artifact” can be applied to almost anything recovered at a particular site, from pottery to remnants of post holes. Therefore, it can be very cumbersome to discuss every type of artifact that has the potential to be unearthed at an archaeological site. For the purposes of this discussion, the
focal point will be a description of the various types of pottery that is unique to the Mississippian tradition, in order to discern the attributes that distinguish it from past cultural patterns. In addition, trade will be addressed in this section, so as to provide examples of how Mississippian populations may have interacted with one another.

Mississippian pottery provides an excellent example of the variability manifested in artifacts. Overall, Mississippian ceramics were quite elaborate and diverse. Ceramic assemblages consisted of a variety of items such as jars, bowls, bottles, funnels, and beakers (Goldstein 1980; Kelly 1990a; Milner 1998). However, Griffin (1967) notes that the most common items are cooking and storage jars and simple bowls. Pottery was classified into two types based upon use: those vessels that served a number of “everyday” functions and those that served a ceremonial purpose (Goldstein 1980). The “everyday” pottery was plain while the ceremonial pottery exhibited intricate detail and fine decoration (Goldstein 1980).

Also, Mississippian ceramics were primarily shell tempered (Conrad 1991; Goldstein 1980; Milner 1998; Morse and Morse 1990), which is a shift from the use of limestone, grog, and grit as temper in Late Woodland and Emergent Mississippian pottery (Milner 1998).

Another important difference between Mississippian culture and that of earlier traditions is the participation in trade networks. The best archaeological evidence for this type of activity comes from the excavation of goods that do not appear to have been assembled at the various sites in which they were discovered or in the form of foreign raw materials. In regards to raw materials, many Mississippian sites have archaeological evidence of these objects that include copper, mica, and flint among others (Brown, et al. 1990). In terms of manufactured items, many sites outside of the American Bottom have remnants of Ramey Incised and Powell Plain ceramics that were thought to reach faraway
areas via trade. Examples of sites in which these types of artifacts have been recovered are the Kingston Lake, Dickson Mounds, and Eveland sites in the central Illinois valley; the Schild and Moss sites from the lower Illinois valley; and Phipps, Kimball, and Brewster sites in the Eastern Plains/Missouri River region (Kelly 1991). More specifically, Dickson Mounds has a number of non-locally manufactured articles. In addition to the American Bottom pottery discussed above, Mill Creek pottery from northwestern Iowa, bone bracelets from the Eastern Plains, marine shell, and chert from southern Illinois have all been recovered at the site (Harn 1980). Finally, Peebles and Kus (1977) have detailed the presence of exotic ritual items at Moundville in the American Southeast.

It has been suggested that trade contact between Mississippian groups could have contributed to the increased presence of infectious disease in these groups. Trade provides an opportunity for individuals to have more person-to-person contact, an act that could have precipitated the interchange of infectious agents in addition to material objects (Goodman, et al. 1984; Lallo and Rose 1979; Manchester 1984).

The Orendorf Population

The central Illinois River Valley has long been a concentration of archaeological research. Long-term investigations at a number of sites, such as Dickson Mounds, have provided an abundance of information and insight into the lifeways of native populations (Harn 1980). It is believed that the Mississippian cultural tradition emerged in this region during the eleventh century A.D. as a likely consequence of a migration of a small group from Cahokia (Harn 1978). However, others dispute the notion that migration was the cause for the appearance of Mississippian culture in the particular area (Steadman 1997; Steadman...
The outcome was seven towns situated in the Illinois River valley, of which Orendorf was one [Harn, 1991 #18; Conrad 1991).

The cemetery of the Orendorf population was excavated during the 1986-1990 field seasons under the supervision of the Upper Mississippi Valley Archaeological Research Foundation (UMVARM) and Western Illinois University (Esarey and Conrad 1981; Conrad 1991; Steadman 1997). Orendorf is the type site for the Orendorf Mississippian phase (approximately A.D. 1150-1250) in the central Illinois River valley (Conrad 1991; Harn 1991). Figure 1 shows the location of this site in relation to others in the area. The site is located in Fulton County, Illinois (see Figure 1), and is considered a Spoon River temple town (Conrad and Emerson 1974). It is believed that Orendorf was the first of the many settlements to be inhabited in the region and was probably abandoned as new towns were built within the valley during the Larson phase. This is evidenced by the limited temporal span and the unique design of Orendorf's ceramic assemblages (Harn 1978). Table 1 illustrates a temporal sequence of cultural traditions for the central and lower Illinois valleys and the American Bottom region.

The Orendorf site consists of five settlements situated on a bluff top (Conrad 1991). However, even with the presence of multiple settlements, the bulk of research and publication is given to only three of them, designated Settlements B/C, C, and D, respectively. The estimated population size of Settlement C is 135 to 720, based solely upon the house sizes of the time period (Santure 1981). However, Santure (1981:56) admits that this range is too broad and states that the formulas utilized in the calculation are inadequate for population estimates; she then modifies the estimate to 400-500 individuals.
Figure 1 Map of central Illinois valley. From Harn (1980).
Table 1  Temporal Sequence for Cultural Phases in the Central and Lower Illinois Valleys and the American Bottom. From Steadman (1998:309).

<table>
<thead>
<tr>
<th>A.D.</th>
<th>Cultural Period</th>
<th>Central Illinois Valley</th>
<th>Lower Illinois Valley</th>
<th>American Bottom</th>
</tr>
</thead>
<tbody>
<tr>
<td>1500</td>
<td>Oneota</td>
<td>Bold Counselor</td>
<td>Vulcan</td>
<td>Vulcan</td>
</tr>
<tr>
<td>1400</td>
<td></td>
<td></td>
<td></td>
<td>Sand Prairie</td>
</tr>
<tr>
<td>1300</td>
<td></td>
<td>Larson</td>
<td>Sand Prairie</td>
<td>Sand Prairie</td>
</tr>
<tr>
<td>1200</td>
<td>Mississippian</td>
<td>Orendorf</td>
<td>Moorehead</td>
<td>Moorehead</td>
</tr>
<tr>
<td>1100</td>
<td></td>
<td>Eveland</td>
<td>Stirling</td>
<td>Stirling</td>
</tr>
<tr>
<td>1000</td>
<td>Emergent</td>
<td>Sepo</td>
<td>Jersey Bluff</td>
<td>Stirling</td>
</tr>
<tr>
<td>900</td>
<td>Mississippian</td>
<td>Maples Mills</td>
<td>Late Woodland</td>
<td>Emergent</td>
</tr>
<tr>
<td>800</td>
<td>and Late Woodland</td>
<td>Bauer Branch</td>
<td></td>
<td>Mississippian</td>
</tr>
</tbody>
</table>

A number of archaeological attributes are suggestive of Mississippian influence at the Orendorf site. Flotation as well as artifact analysis point to a subsistence practice that relied upon maize cultivation. Maize debris has been recovered in flotation samples from Settlement C (Good 1981). Artifacts indicative of maize agriculture include bison hoes (procured by trade), and perhaps, storage jars (Conrad 1991).

The ceramic patterns at Orendorf are also consistent with the Mississippian type. There were shell tempered wares; however, styles were elaborate and new designs were introduced during the Orendorf phase. For example, the curvilinear and pseudo-scroll designs seen on some ceramics are unique to this phase, as these styles do not appear to be manifested in other regional phases, such as Larson (Conrad 1991). However, even with such meticulous decoration, the most common pottery vessels unearthed at Orendorf appear to be plain jars (Santure 1981). Other ceramic items of use to the individuals at the site
include plates, bowls, beakers, and water bottles. Examples of non-ceramic artifacts include large sandstone effigy pipes, discoidals, and corner notched non-triangular points (Conrad 1991).

Like other Mississippian sites, it appears that Orendorf took part in some form of a trade system, as supported by the presence of non-locally manufactured artifacts. Examples of these items include: several species of shells from the Florida coasts, Bell Plain effigy items, Mound Place incised bowls (from the central Mississippi valley), cherts from other Illinois counties, and salt pans from the American Bottom (near the Cahokia region). Also, it appears that Orendorf traded with individuals from the Missouri Basin, as suggested by the presence of tools manufactured from bison bones. Bone bracelets that are not of the central Illinois valley origin are also found, and could have come from east or west of the region. In addition, influence from southern sites is displayed in the form of engravings on pipes, as well as the types of bead assemblages. Finally, exotic items are also seen in mortuary contexts, as will be discussed shortly (Conrad 1991).

Mississippian tradition is also identified in the mortuary customs practiced at Orendorf. At the site, individuals were usually buried in cemeteries or mounds on or in proximity of a bluff (Conrad 1991). While most interments were of the extended variety, other types were present. Conrad states “although most burials were extended, there were in decreasing frequency disarticulated bundle and pile, semiflexed, flexed, and possible cremated burials” (1991:136). A charnel house was also excavated at the site and was situated on a platform (Conrad 1991).

A number of controlled and uncontrolled (i.e. artifact looting) excavations have recovered a variety of grave goods were associated with several burials. Types of artifacts
ranged from simple utilitarian items to non-locally manufactured objects. Non-exotic items include, but are not limited to: jars, beakers, plates, bone pins, arrow points, and celts, respectively. Instances of faraway items are Mill Creek, Burlington, and Kaolin chert and marine shell jewelry (Conrad 1991). Conrad (1991) does not really provide an explanation of a potential relationship between grave furniture and differences in status, so it is difficult to assess the presence of social stratification when speaking of mortuary practices.

**Summary of Mississippian Influence at Orendorf**

From the evidence provided, it can be seen that Orendorf was part of the Mississippian cultural tradition. First, it is apparent that Orendorf practiced maize agriculture, based upon soil analyses and artifacts associated with maize cultivation. Second, interment in mounds is another important Mississippian characteristic. Third, Mississippian influence is demonstrated in the types of artifacts (e.g. shell tempered ceramics) unearthed at the site, as well as the presence of non-locally manufactured items.

It is important to have an understanding of the cultural background of the Orendorf people. Orendorf is a Mississippian society with many characteristics that could make it susceptible to various pathogens. The knowledge of such characteristics is important in order to understand the potential for infectious disease in this population, especially TB and treponematosis.
CHAPTER THREE
BASIC HUMAN OSTEOLOGY

Before one can fully appreciate the skeletal manifestations of TB and treponematosis, as well as the results of this study, it is important to have some background knowledge of basic human osteology. The field of osteology is quite detailed and intricate, with a plethora of books and publications devoted specifically to this field. However, for the purposes of this discussion, only one book (White 1991) will be utilized in order to address a few fundamental points. These include: anatomy of a bone, body orientation terminology, and external anatomy of a vertebrae. It is important to note that this chapter is not intended to provide an exhaustive description of the above topics, but rather to supply the reader with the most fundamental knowledge necessary to understand skeletal TB and treponematosis.

Anatomy of a Bone

Bone is made up of two categories of skeletal tissue: compact and spongy bone. Compact bone is also known as cortical bone, and is overall, denser in nature than its counterpart. On the other hand, spongy bone is much less condensed and macroscopically has a makeup analogous to a lattice structure. This type of bone is also identified as cancellous, or trabecular bone. Compact bone is usually thickest in the shafts of bones, while spongy bone is concentrated more towards the ends of bones, in vertebral centra, or within flat bones. The differences in morphology are related primarily to the functions of these types of bone. The structure of spongy bone allows it to absorb stresses and forces placed upon the ends of bones during movement, while compact skeletal tissue works to maintain the integrity of the bone itself (White 1991).
Figure 2 shows a cross-section of a femur. From this diagram, it is easy to identify the location of compact bone in the shaft and the spongy bone at the ends. The anatomical term for the shaft is diaphysis, while the ends are known as epiphyses. Between these is the region referred to as the metaphysis. These regions are also referred to as ossification centers, as these are the areas in which a bone grows (White 1991).

The positions of the periosteum, endosteum, and medullary cavity are also demonstrated in Figure 2. The periosteum is the outermost aspect of a bone and is a membrane that protects its external surface. It is not possible to recover the periosteum in an archaeological context, as it is soft tissue that is only present while an individual is alive. Working inward, the endosteum is an area of active osteological tissue that is within the diaphysis. It is important to note that both the periosteum and the endosteum contain osteoblasts, that is, cells that lay down new bone. Finally, the medullary cavity is the innermost portion of a bone. It houses yellow marrow, a material that is primarily composed of fat cells (White 1991).

**Anatomical Directions**

In order to adequately describe any sort of skeletal pathology, it is imperative to use the proper terminology so that the reader can best visualize that which is being detailed. This nomenclature is based on the specimen being in anatomical position, that is, one in which an individual is facing forward, with palms turned outward. There are several terms used for this task, but those of most concern for this study are: anterior/posterior, superior/inferior, medial/lateral, and proximal/distal. Figure 3 demonstrates this terminology.
Figure 2 Cross-section of a femur. Illustration courtesy of J. Dorn.
Figure 3 Anatomical directions. Illustration courtesy of J. Dorn.
Anterior is toward the front of the body, or chest-side. The opposite of anterior is posterior, or toward the back side of the body. For example, the heart is anterior to the spine. Superior is in the direction of the head, while inferior is toward the feet. So, in anatomical terminology, the head is superior to the feet. Medial and lateral deal with relationship toward the midline of the body. Medial is toward the midline; lateral is away from the midline. Therefore, the nose is medial to the ears. Finally, proximal is nearer to the axial skeleton (the head and spinal column), while distal is further away. For example, the elbow is distal to the shoulder (White 1991).

**External Anatomy of a Vertebrae**

The spinal column is made up of five different types of vertebrae. These are (from superior to inferior): cervical, thoracic, lumbar, sacral, and coccyx. Figure 4 displays the terms to be discussed via superior and lateral views of a thoracic vertebrae. The most anterior portion of a vertebrae is known as the centrum, or body and is largely made up of spongy bone. On the superior and inferior surfaces of the centrum are ring-like features, known as epiphyseal rings. These rings are the regions where vertebrae grow, and can be extremely useful for estimating the age of an individual. The neural arch is just posterior to the centrum and encircles the spinal cord on its lateral aspects. The lamina is the intermediary connection between two posterior portions of the vertebrae, the pedicle and the spinous process (White 1991).
Figure 4 Superior and lateral view of a thoracic vertebrae. Illustration courtesy of J. Dorn.
CHAPTER FOUR
TUBERCULOSIS AND TREPONEMATOSIS: AN OVERVIEW

The overall disease processes of TB and treponematosis are relatively complex and can be difficult to understand. This chapter will attempt to provide the reader with a fundamental knowledge of the pathophysiology of these diseases in order to comprehend their eventual skeletal involvement. Further, a basic explanation of the evolution of TB and treponematosis is also offered so that one can understand how prehistoric populations could have been affected by these conditions.

Tuberculosis: Pathogenesis, Pathophysiology, and Skeletal Effects

Tuberculosis is a disease that has a lengthy history in human populations. This disease has been identified in skeletal remains from Nubia that are possibly as old as 13,000 years (Ortner 1999) and is considered the most ubiquitous infectious disease in the world (Friedland 1999). In fact, *Mycobacterium tuberculosis*, the pathogen most commonly associated with human TB (Braun, et al. 1998; Ortner 1999), is responsible for more deaths worldwide than any other infectious agent (Ostroff and Leduc 2000). *Mycobacterium tuberculosis* is an acid-fast bacillus (Aufderheide and Rodriguez-Martin 1998; Grosset 1993; Price 1992; Steinbock 1976; Wolinsky 1994) of the order Actinomycetales (Friedland 1999; Wolinsky 1994). It should be noted here that *M. tuberculosis* is part of large *Mycobacterium* complex that also includes a number of additional species, such as *M. bovis*, *M. africanum*, *M. microti* (Aufderheide and Rodriguez-Martin 1998; Clark, et al. 1987; Stead 2000; Stead, et al. 1995) as well as the *M. avium*, *M. fortuitum*, *M. chelonei*, *M. kansasii*, and *M. marinum* species (Aufderheide and Rodriguez-Martin 1998; Thoen 1988). Human tuberculosis, or that
caused by *M. tuberculosis*, is most often associated with pulmonary disease, although any organ of the body can be affected (Steinbock 1976). The most frequent mode of transmission is airborne, with an infected host spreading TB to others by coughing up sputum laden with bacteria. The sputum is composed of moisture droplets that are subsequently inhaled by other person(s).

Tuberculous infection occurs in two phases, a primary infection and a secondary, or reinfection, phase (Aufderheide and Rodriguez-Martin 1998). The primary infection frequently begins with the inhalation of the *Mycobacterium* organism. Once the pathogen has entered the body, it travels to the alveolar surface of the lung, where phagocytosis begins. Phagocytosis of the bacillus is accomplished by the alveolar macrophage (Grosset 1993); (Friedland 1999) and may be augmented by pulmonary surfactant protein (Friedland 1999). Also, phagocytosis stimulates such cytokines as tumor necrosis factor (TNF), which plays a crucial role in later granuloma formation (Friedland 1999). In addition, the bacillus may continue to multiply within the area of primary infection and drain into regional lymph nodes (Price 1992). If the bacillus survives this initial immune response and goes untreated (i.e. no pharmacological intervention), it may be isolated by a granulomatous scar tissue that is also referred to as a granuloma. By definition, a granuloma is “...chiefly composed of macrophages activated in response to mycobacterial antigens and adjuvants” (Daniel and Ellner 1993:81). Another way of defining a granuloma is as a result of a complex interaction between the host’s immune system, tissue factors, and other proteases in combating the bacillus (Friedland 1999). This granuloma will stay in a dormant phase until reactivated (Aufderheide and Rodriguez-Martin 1998).
The secondary phase of infection starts with a reactivation of the dormant pathogen by breakdown of the granulomatous capsule that houses the latent bacteria. This breakdown may be precipitated by additional exposure to tubercle bacilli (Aufderheide and Rodriguez-Martin 1998; Grosset 1993) or other factors such as immunosuppression, malnutrition, and possibly, vitamin D deficiency (Friedland 1999). Upon reactivation, the tubercle bacilli can disperse to other areas of the body via lymphohematogenous dissemination, which is usually self-contained to a specific region, or by hematogenous dissemination that may be considerably more systemic (Price 1992). It should be noted that an individual in this stage is highly contagious and may spread the disease to others by expulsion of sputum containing the bacteria e.g. (Aufderheide and Rodriguez-Martin 1998; Wolinsky 1994).

The spread of TB is not confined to soft tissue alone, for the skeleton can be affected in the secondary phase. Although any bone of the body may be affected (Roberts 1999), these pathogens tend to congregate in those areas of the skeleton that have an extensive blood supply, such as spongy bone (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981). As previously mentioned, the bacilli travel from the lungs to other areas of the body and hence, the skeleton, via the bloodstream. In adults, the metaphyses and epiphyses of long bones have much cancellous bone and are often affected; in infants and children, bones of the hands and feet contain a large amount of this type of bone and are frequent sites of involvement. However, involvement of the spine, ribs, and sternum is not age-specific since the amount of cancellous bone in these areas does not differ significantly by age (Ortner and Putschar 1981).

Tuberculosis is a lytic disease that causes resorption of bone tissue (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981). The invasion of the tubercle bacilli into
the skeleton and the subsequent immune response are the factors responsible for the
destruction. Various leukocytic enzymes destroy bone (Steinbock 1976), with little
discernible regeneration or healing of the lesions (Aufderheide and Rodriguez-Martin 1998;
Morse 1967; Ortner and Putschar 1981; Steinbock 1976). The lesions are often oval-shaped
(Buikstra and Cook 1981) and have been described as “smooth-walled,” possibly indicating
some sort of healing processes (Baker 1999; Buikstra and Cook 1981).

The spinal column appears to be most common site of tuberculous involvement in the
skeleton (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981; Tuli 1975),
with the anterior vertebral bodies (centra) being constructed predominately of highly
vascularized cancellous bone e.g. (White 1991). Therefore, these elements are most prone to
infestation by tubercle bacilli (Braun, et al. 1998). These bacilli invade one or more centra
and produce localized areas of infection known as abscesses (Aufderheide and Rodriguez-
Martin 1998; Ortner and Putschar 1981). Lasting abscesses will eventually destroy the
cancellous bone (Aufderheide and Rodriguez-Martin 1998); extensive resorption and
destruction will cause the centra to collapse. The result is an anterior curvature of the spine,
or kyphosis. Kyphosis that is the result of substantial tuberculous destruction is termed
Pott’s disease, and is usually only manifested in extreme cases (Aufderheide and Rodriguez-
Martin 1998; Ortner and Putschar 1981). Although the posterior elements of the spine (i.e.
neural arches, transverse and spinal processes) can suffer some destruction, overall it is not a
common occurrence (Braun, et al. 1998; Kelley and El-Najjar 1980; Morse 1967; Morse
1969). In the rare instances that posterior vertebral involvement is present, it is usually
secondary to extensive destruction of the centra (Buikstra 1976b).
An important point to note is that abscesses are not localized to the site of initial infection in the vertebrae. Infection can spread to adjacent vertebrae through the intervertebral discs or by the anterior spinal ligament. If infection of the anterior spinal ligament penetrates the psoas muscle of the lower back, it will likely advance distally through the muscle. The result is an eventual abscess of the psoas muscle (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981), which is an important indicator of TB, especially in a paleopathological context. For example, the lesser trochanter of the femur and the iliac fossa can exhibit lesions that may be useful in diagnosing such an abscess (Buikstra and Cook 1981), in addition to the presence of an ossified psoas muscle itself (Ortner and Putschar 1981).

In terms of frequency, the synovial joints are the next most common site of TB infection in the skeleton (Ortner and Putschar 1981). This is likely due to the large concentration of cancellous bone in these joints, which makes them susceptible to invasion by the tubercle bacilli. By definition, synovial joints are relatively large joints that have a fluid-filled capsule that allow for a considerable range of movement. Examples of synovial joints are the hip and the knee, which next to the spine, are the most commonly affected regions of the skeleton (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981). When the tubercle bacilli invade synovial joints, two principal changes develop. First, the articular surfaces tend to exhibit the typical resorptive changes expected with TB. However, these alterations to the joint surfaces are ordinarily confined to areas of ligament or synovial tissue attachment (Ortner and Putschar 1981). In fact, a characteristic feature of tuberculous arthritis “...is that it tends to produce an identical lesion on the two opposing surfaces of the joint” (Steinbock 1976). Second, the joint surfaces are eventually broken down and exhibit a
granular appearance that is analogous in nature to sandpaper. In addition, the afflictions suffered by synovial joints are unilateral; that is, seldom is the same joint affected on the opposite side of the body (Auferheide and Rodriguez-Martin 1998).

The ribs may also display lesions attributed to TB. Most often, these changes are in the form of scattered periostitis on the internal aspect of adjacent ribs, though a single focus of infection may be demonstrated. These alterations are ordinarily seen on the shaft of the rib, as the head and neck are seldom involved. The cause of these lesions is likely due to the direct spread of the tubercle bacilli from the pulmonary pleura to the ribs, with the location of the rib lesions corresponding directly with areas of chronic TB infection in the lung (Kelley and Micozzi 1984).

**Evolution of Tuberculosis**

The origin of TB in human populations is a topic that spans numerous scientific disciplines, from anthropology to molecular biology. Together, these disciplines have provided a comprehensive explanation of how this disease came to be such an important facet of human evolution. The purpose of this section is to provide a brief explanation of the paleoepidemiology of TB.

As previously stated, tuberculosis has been identified in human remains from Nubia that are likely 13,000 years old (Ortner 1999). However, the earliest cultural documentation of human TB infection comes from Egypt, in the form of figurines that display affliction with Pott’s disease (Manchester 1984). Nonetheless, tuberculosis was in all probability endemic to animal populations before it was a major problem in human groups (Daniel, et al. 1994; Manchester 1984). A disease in considered endemic when it maintains a constant presence
in a particular population; this is in contrast to epidemic, where the amount of a certain disease in a group exceeds what would be normally expected e.g. (Gordis 1996). In fact, it appears that the responsible Mycobacterium for such an endemic presence is *M. bovis* (Daniel, et al. 1994). Domestic animals such as cattle harbored this pathogen; as their own density increased through herding activities, *M. bovis* spread within herds with little difficulty (Manchester 1984; Ortner 1999). Inoculation of humans with this Mycobacterium likely occurred as they consumed raw meat and milk from infected animals (Clark, et al. 1987; Haas and Haas 1999; Ortner 1999; Stead 2000). Further, it has been suggested that the origination of human *M. tuberculosis* was the result of a mutation of this bovine strain (Clark, et al. 1987).

Once *M. tuberculosis* was established in humans, it only required a few conditions in order to become epidemic. These conditions include high population density, crowding, and sedentism as TB is easily spread between individuals in these environmental circumstances (Buikstra 1999; Buikstra and Cook 1981; Clark, et al. 1987; Cockburn 1963; Daniel, et al. 1994; Haas and Haas 1999; Manchester 1984; Roberts and Manchester 1997; Stead 2000). This differs drastically from *M. bovis* in that the bovine strain “...can be endemic in a population for centuries with little or no chance of becoming epidemic even in crowded conditions” (Stead 2000:14). Therefore, it is possible that populations with lower population densities than would be expected for “classic” TB could still have suffered from this affliction, with *M. bovis* as the causative agent. This statement is in direct conflict with those who believe that prehistoric groups in the Americas did not have an adequate population density to support this disease (Cockburn 1963: Morse 1969). However, in their defense,
perhaps they were referring to TB caused by *M. tuberculosis*, and not *M. bovis*, although this is not specified in the literature.

**Treponematosis: Pathogenesis, Pathophysiology, and Skeletal Effects**

Like TB, treponematosis is an infectious condition that has an extensive history in human groups. Skeletal evidence of this disease has been found in both the Old and New Worlds (El-Najjar 1979; Powell 1991; Stirland 1991) and is the result of a bacterial spirochete of the genus *Treponema* (Aufderheide and Rodriguez-Martin 1998; Hudson 1965; Ortner and Putschar 1981). Much controversy has emerged from the debate on whether this disease is a syndrome of four different pathological conditions (pinta, yaws, endemic/bejel, and venereal/acquired) caused by different microorganisms or if it is simply varying clinical expressions of a single *Treponema* bacteria (Aufderheide and Rodriguez-Martin 1998; Hackett 1967; Hudson 1965; Ortner and Putschar 1981). For example, Hackett (1967) contends that each of the treponemal diseases should be regarded as the result of its own specific bacteria, thereby establishing four separate conditions labeled collectively as the human treponematoses. Therefore, *T. carateum* is responsible for pinta, *T. pertenue* for yaws, *T. pallidum endenicum* for endemic, and *T. pallidum pallidum* for venereal (Aufderheide and Rodriguez-Martin 1998). Some authors even give yaws a subspecies: *T. pallidum pertenue* (Chulay 2000). Conversely, Hudson (1965) suggests that *Treponema pallidum* is responsible for all four conditions, based upon the argument that there is no demonstrable morphological differences between the microorganisms when viewing them microscopically and that there is no known analysis to distinguish them. Roberts and Manchester (1997) state “if they are but different clinical manifestations, then the disease
entity is the treponematosis.” It is not the point of this thesis to resolve this issue, but in accordance with the majority of clinical literature, will discuss each separately, based upon geography and clinical manifestations. When speaking of skeletal manifestations, the diseases will be dealt with as one entity.

Geographically, pinta is found in rural western populations and in the tropical areas of South and Central America. Pinta manifests itself as skin lesions that are usually confined to the face and extremities (Aufderheide and Rodriguez-Martin 1998; Chulay 2000), while internal organs and bone are spared (Aufderheide and Rodriguez-Martin 1998). Transmission is accomplished through contact between broken skin and a contagious lesion; once present in a new host, the organisms reproduce at the site of infection and are subsequently disseminated throughout the body via the blood and lymphatic systems (Chulay 2000). After a primary inoculation and the following seven to twenty day incubation period, a primary lesion will appear followed by erythematous lesions of varying hues (white, red, blue, pink, yellow, and violet) that cover the body (Brown, et al 1970). It is important to understand that pinta does not cause skeletal lesions.

Like pinta, yaws is also a disease of rural populations. Areas of high occurrence include warm, tropical regions of Africa, South America, southeast Asia, and Oceania (Aufderheide and Rodriguez-Martin 1998; Chulay 2000). Skin-to-skin contact is also the mode of transmission, when one’s broken skin touches infectious discharge from a yaws lesion (Chulay 2000). Incubation is relatively short (3 to 5 weeks), after which primary lesions erupt on the extremities; these lesions heal suddenly in approximately six months. In the coming weeks to months, secondary lesions will emerge and in the absence of a treatment regimen, will continue to plague an infected individual for the duration of the illness. These
lesions can become large ulcers or they may display a dry or “scaled” appearance (Chulay 2000:2492). It is important to note that unlike pinta, yaws will affect bone (tibia, fibula, clavicle, femur, ulna, radius, bones of hands and feet) in chronic cases (Aufderheide and Rodriguez-Martin 1998; Chulay 2000; Ortner and Putschar 1981).

Endemic syphilis, or bejel, also demonstrates osteological involvement (Aufderheide and Rodriguez-Martin 1998; Chulay 2000; Ortner and Putschar 1981). This disease is primarily a condition of juveniles who reside in rural areas of poor hygiene and low status, such as eastern Europe, Africa, southwest Asia, and Africa (Aufderheide and Rodriguez-Martin 1998; Brown, et al. 1970; Chulay 2000). Transmission can occur through direct spread or indirect means (e.g. sharing eating and drinking utensils) (Aufderheide and Rodriguez-Martin 1998; Chulay 2000). Endemic syphilis usually presents itself in the form of oral lesions that are difficult to detect, hence the easy transmission (Chulay 2000). Lymphadenopathy and diffuse rashes of the mouth and pharynx are typical of the secondary phase of bejel, while late expression of the disease includes skeletal lesions (same bones as yaws as well as nasal-palatal involvement) (Aufderheide and Rodriguez-Martin 1998; Chulay 2000).

Venereal syphilis is conceivably the most well known of the treponematoses, especially in the modern western world. This form has an unlimited global distribution, unlike its counterparts (Aufderheide and Rodriguez-Martin 1998) and has no climatic requirements (Steinbock 1976). Venereal syphilis is a systemic illness that affects the reproductive, integumentary, gastrointestinal, renal, cardiovascular, nervous, and skeletal systems (Musher and Baughn 1998; Tramont 2000). It is transmitted most often via sexual
intercourse, although congenital transmission from an infected mother to the fetus is also possible (Aufderheide and Rodriguez-Martin 1998; Steinbock 1976; Tramont 2000).

Infection begins with the entrance of the *T. pallidum* into the body, with spread throughout the body via the blood and lymphatic systems (Tramont 2000). It is maintained that the chronic nature of syphilis infection is the result of a switch from a cellular to a humoral immune response (Tramont 2000). The disease then proceeds through three clinical phases, labeled primary, secondary, and tertiary, respectively, and a non-clinical latent phase (Musher and Baughn 1998; Tramont 2000).

After an average incubation period of fourteen to twenty-one days, the primary phase of venereal syphilis begins with a painless red sore that is located at the site of inoculation (Musher and Baughn 1998; Tramont 2000). However, there are some differences in the literature regarding the labeling of this lesion. Some identify the initial lesion as well as those with exudate as chancre(s) (Tramont 2000), while others give this label solely to those lesions that have broken open, producing a colored drainage (Musher and Baughn 1998). Further, it has been proposed that the development of an ulcerative lesion occurs only if a person is infected with a large dose of the pathogen; a small dose will only produce a small lesion with no exudate (Tramont 2000). Regardless of the labeling, primary phase lesions are accompanied by regional lymphadenopathy and usually heal within three to eight weeks (Musher and Baughn 1998; Tramont 2000).

The secondary phase of venereal syphilis is widespread and affects a number of body systems. These symptoms are the outcome of the dispersion of the microbe from the primary lesions and often appear two to ten weeks after the primary phase, although this time frame varies between persons. Perhaps the most outward expression of the disease at this stage is
the mosaic of integumentary manifestations that include a range of macular, papular, and pustular lesions (Musher and Baughn 1998; Tramont 2000). These lesions originate in the trunk region and disseminate to the rest of the body (Tramont 2000). Also appearing in the secondary phase are highly infectious lesions referred to as *condyloma lata* (or *latum*), and are confined to warm, potentially moist areas, such as the groin, inner thighs, axillae, oral membrane, between fingers and toes, and the anus. Hair loss, or alopecia, is another common expression of secondary venereal syphilis. In addition, a number of other body systems can be affected in ways that are specific to a particular system. For example, the skeletal system is affected in the form of periostitis, the kidneys suffer glomerulonephritis, and headaches plague the central nervous system (Musher and Baughn 1998; Tramont 2000).

Between the secondary and tertiary phases of venereal syphilis is what is known as the latent stage, in which there are no outward clinical manifestations of the disease; the only way to discern the presence of infection is with a positive serological test (Musher and Baughn 1998; Tramont 2000). The final stage of the disease, commonly referred to as the tertiary (late) phase, follows this latent period. Both the latent and tertiary phases are of variable duration in individuals. Like the secondary phase, the tertiary phase can also affect any organ of the body; however, the cardiovascular and the central nervous systems appear to suffer considerable consequences of these effects (Musher and Baughn 1998; Tramont 2000). Cardiovascular syphilis often demonstrates as aortitis (Musher and Baughn 1998; Tramont 2000), with occasional displays of aortic aneurysms, congestive heart failure, and left ventricular hypertrophy (Musher and Baughn 1998). Neurosyphilis can present itself in a number of ways that affect both the brain and spinal cord. These symptoms include, but are certainly not limited to: psychosis, manic depressive behavior, hyperactive reflexes, slurred
speech, decreased memory, stroke, ataxia, parasthesias, and even death (Musher and Baughn 1998; Tramont 2000).

Another facet of late venereal syphilis is the benign, or gummatous syphilis. This is characterized by the presence of gummas/gummatas (Musher and Baughn 1998; Tramont 2000). Tramont (2000:2482) defines gummas as “...single or multiple and vary in size from microscopic defects to large, tumor-like masses...the cutaneous manifestations range from superficial nodules to deep granulomatous lesions, which may break down to form punched-out ulcers.” The scars of these gummas are frequently arranged in a circular or arc-shaped pattern. Gummas can also attack any organ, including skeletal tissue (Musher and Baughn 1998; Tramont 2000).

Overall, the osteological effects of treponematosis are quite comparable morphologically; therefore, it is a daunting task to attempt to diagnose with confidence the specific type (yaws, endemic, venereal) in dry bone (Aufderheide and Rodriguez-Martin 1998; Morse 1969; Ortner and Putschar 1981). However, researchers working with treponemal lesions suggest that such discrimination is possible, if certain epidemiological considerations (i.e. population frequency and demographics) as well as lesion attributes and distribution are taken into account during diagnosis e.g. (Cook 1979; Powell 1991; Rothschild and Rothschild 1995; Schermer, et al. 1994). Since the purpose of this study is to only determine the presence of treponematosis in the Orendorf population, no attempt will be undertaken to determine the specific type responsible.

Skeletal lesions of treponematosis result from both osteoblastic and osteoclastic activity and can be classified into two specific categories: gummatous and nongummatous. Gummatous lesions are primarily lytic and are generally characteristic of advanced disease...
These lesions can be found on long bones in addition to the skull (Aufderheide and Rodriguez-Martin 1998). After the initial lytic response, healing processes attempt to repair the damage; however, such responses customarily result in an irregular, rough appearance around the lesion (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981) that has been described as “worm eaten” (Ortner and Putschar 1981).

Often, the craniofacial bones exhibit much destruction due to gummatous lesions. Necrotic activity can completely take over any region of the skull, although a focal point of involvement is the frontal, nasal, and palatal bones (Aufderheide and Rodriguez-Martin 1998; Morse 1969; Ortner and Putschar 1981). In severe cases of treponematoses process, the cranial will demonstrate an extremely uneven topography that is termed caries sicca (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981).

Nongummatous lesions are much less destructive than gummatous lesions. Those lesions considered as nongummatous are commonly in the form of periostitis and osteitis (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981; Steinbock 1976). Most often, these pathological changes affect the tibia, fibula, clavicle, femur, radius, and the ulna, but do not spare any of the long bones (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981). On the tibia, substantial periosteal deposition on the anterior shaft is referred to as a “saber shin” deformity and is a defining characteristic of treponematoses (Aufderheide and Rodriguez-Martin 1998; Morse 1969; Ortner and Putschar 1981; Steinbock 1976). In fact, Steinbock (1976:102) provides a comprehensive definition of this deformity as “…the resemblance of the tibia to a calvary saber is due to the marked subperiosteal apposition of new bone on the anterior surface (shin) of the tibia. The new bone is laid down parallel to
the cortex and tends to remain distinct from it.” Other nongummatous reactions include the narrowing of the medullary cavity of the long bones by increased cortical thickening and trabecular bone growth (Aufderheide and Rodriguez-Martin 1998).

**Evolution of Treponematosis**

The evolution of treponematosis is centered around two competing hypotheses regarding the coevolution of humans and the pathogen in the development of the disease. These ideas were first addressed at the beginning of the discussion of treponematosis, and will be further expanded on at this time. The first of these hypotheses is that treponemal infection arose in equatorial Africa during the Paleolithic period and was a childhood affliction spread exclusively by direct skin-to-skin contact. From the hot, humid climate of sub-Saharan Africa, the hunter-gatherers dispersed throughout the world; when they encountered different climatic conditions, treponematosis altered itself. With this drier and less humid geography, treponematosis relocated to those areas of the body that are more moist (i.e. mouth, armpits, groin) and transformed into endemic syphilis. The clinical manifestations of endemic syphilis reflected this change; the skin rashes associated with yaws were replaced by lesions that were fond of warm, moist bodily areas. In addition, endemic syphilis was still seen as a childhood disease that had nothing to do with sexual contact. However, sexual contact played a crucial role in the formation of venereal syphilis. It is further hypothesized that the development of venereal syphilis resulted from the rise of urbanization. With urbanization, there was a slight increase in personal and community hygiene in urban areas; therefore, individuals did not have their first exposure to treponematosis until the age of sexual intimacy. The outcome was venereal syphilis that was
disseminated throughout the world via high levels of promiscuity and prostitution that is
often linked with urban populations (Hudson 1965).

It is interesting to note that Hudson (1965) really does not discuss pinta in his scheme
of treponemal evolution. This omission is contrasted with the competing hypothesis
proposed by Hackett (1967). His theory does not assume a natural biological continuum for
treponemal disease in which all forms are caused by the same microbe (Hudson 1965).
Rather, Hackett (1967) envisions the four syndromes as caused by their own respective
pathogens that basically occurred via mutation from the ancestral treponeme. According to
Hackett (1967:157), pinta was the first step in treponemal evolution and probably “...arose
from an animal infection in the Euro-Afro-Asian land mass, perhaps before about 20,000
B.C. and had extended through the then accessible world by about 15,000 B.C.” The second
of the treponemal diseases to emerge was yaws around 10,000 B.C. This was likely the
consequence of a mutation of the pinta pathogen and occurred in warm, humid climates of
the African and Asian continents. The third step of this evolution was the appearance of
endemic syphilis that resulted from a mutation of the yaws treponeme. The driving force
behind this transformation was the selection by the mutant microbes of warm, dry climates
that were prevalent after the last African and Asian glaciations at approximately 7000 B.C.
The fourth and final syndrome to emerge was venereal syphilis in crowded, urban areas. In
basic agreement with Hudson (1965), Hackett (1967) contends that the venereal treponeme
evolved due to the lack of childhood exposure to treponemal infection, coupled with changes
in hygiene and cultural mores, such as the increase in clothing (Hackett 1967).

To reiterate the main points regarding the paleoepidemiology of treponematosis, it is
felt by some that all manifestations of treponematosis are caused by one specific pathogen, T.
*pallidum* and came about via a biological gradient, dictated by climatic changes (Hudson 1965). On the other hand, others believe that treponematosis is the result of four distinct pathogens that arose via mutation from one another (Hackett 1967).
CHAPTER FIVE
MATERIALS AND METHODS

Examining ancient skeletal remains in order to assess the health of past populations is certainly a very challenging process. While it is easy to document specific lesions on bone, it is altogether a more difficult task to diagnose the responsible disease process. This difficulty arises from the fact that many conditions can produce very similar skeletal manifestations (Aufderheide and Rodriguez-Martin 1998; Buikstra 1976a; Buikstra and Cook 1980; Buikstra and Cook 1981; Ortner and Putschar 1981; Schwartz 1995). However, paleopathologists have adapted (from clinical medicine) a method for dealing with such similarities. This method, known as differential diagnosis, is one that has been used often in paleopathological research (Buikstra 1976a; Buikstra 1976b; Buikstra and Cook 1981; Kelley and El-Najjar 1980). This study acknowledges the usefulness of differential diagnosis when investigating the presence of infectious disease and thus employs the method in order to deduce the presence of TB and/or treponematosis in the Orendorf remains.

This chapter will first provide a brief description of the Orendorf sample and the remains that are examined for the study at hand. What will follow is a discussion of measures of disease frequency from an epidemiological perspective, as well as a more detailed description of the methodology employed in this project (i.e. differential diagnosis).

The Orendorf Sample

As previously stated, the Orendorf cemetery was excavated during the 1986-1990 field seasons under the direction of UMVARF and Western Illinois University. The minimum number of individuals recovered during this time is 284 (Steadman 1997). Both
juveniles (age less than 15 years) and adults (age equal to or greater than 15 years) are included in the entire cemetery. However, due to time constraints and preservation difficulties, only adults comprise the subsample. Therefore, the subsample for this is study is 117 adult individuals. Also, for this investigation, an individual is defined as an adult burial that has a single complete or fragmentary skeletal element present, whether it is cranial or postcranial. The research was conducted at the Iowa State University Physical Anthropological Laboratory and Western Illinois University from approximately July 1999 to July 2000. Currently, the remains are housed at Binghamton University Bioarchaeological Laboratory.

Measures of Disease Frequency

Epidemiology is a very important scientific discipline. It provides a plethora of information about the elaborate interaction between humans, pathogens and their transmission, and the environment. Specifically, epidemiology is defined as “the study of how disease is distributed in populations and of the factors that influence or determine this distribution” (Gordis 1996:3). In epidemiology, the human population is of greatest interest. According to Beaglehole (1993), a population is a group of individuals that are bound together temporally and geographically.

In terms of age, epidemiology is a relatively young science. However, it can trace its roots back some two-thousand years ago, when Hippocrates first hypothesized that environmental circumstances can play a role in the occurrence of disease. But it was not until the nineteenth century when John Snow, in a landmark investigation of a cholera outbreak in London, performed the first systematic epidemiological investigation and as a
result, discovered some of the fundamental tenets of epidemiology (Beaglehole, et al. 1993; Gordis 1996). Today, epidemiology is an extremely important science that is utilized to better understand not only infectious disease, but chronic conditions as well. Although epidemiology is more often concerned with disease investigation and prevention in modern populations, it is interesting to note that there are some principles that may be of use to the paleopathologist.

There are a number of concepts that are central to epidemiological investigation. For example, in such investigations, relative risk (RR) and odds ratio (OR) can be used in order to evaluate the risk of developing a disease in the event of an exposure (Beaglehole, et al. 1993; Gordis 1996). However, the purpose of this study is only to consider measures of disease frequency with the Orendorf data, not to determine risk. Frequency is actually composed of two fundamentally important concepts: incidence and prevalence (Beaglehole, et al. 1993; Gordis 1996). But before one can attempt to calculate these figures, it is important to keep in mind that measures of disease frequency are only helpful if there is an accurate and correct estimate of the number of individuals under investigation (Beaglehole, et al. 1993).

Incidence is defined as the number of new cases of a disease in a population at risk during a particular period of time (Beaglehole, et al. 1993; Gordis 1996). Following Gordis (1996:31), the formula for incidence is presented in Figure 5. The key word to remember

| number of new cases of a disease occurring | X 1000 |
| in the population during a specified period of time | |
| number of persons at risk for developing the disease during that period of time | |

**Figure 5** Formula for calculating incidence
when speaking of incidence is “new.” The point of incidence is to determine the number of new cases in a group of people within a specific time period, with no regard for existing cases. Obviously, incidence cannot be measured with ease in paleopathological research in that the antiquity of skeletal remains does not allow researchers to effectively deal with measures of time, i.e. it is not possible to measure new cases of a disease in a skeletal sample. However, prevalence, the other measure of disease frequency, can be particularly helpful to the paleopathologist.

Prevalence is defined as the number of affected individuals in a particular population at a specific point in time (Beaglehole, et al. 1993; Gordis 1996). Gordis (1996:32) views prevalence as “…a slice through the population at a point in time at which it is determined who has the disease and who does not. But in doing so we are not determining when the disease developed.” Prevalence can be influenced by a number of factors that include the severity of illness, the duration of illness, and the number of new cases (Beaglehole 1993:16). Following Gordis (1996:32), the formula for prevalence is presented in Figure 6.

\[
\text{Prevalence} = \frac{\text{number of cases of a disease present in the population at a specified time}}{\text{number of persons in the population at that specified time}} \times 1000
\]

\textbf{Figure 6} Formula for calculating prevalence

Unlike incidence, prevalence deals exclusively with existing cases of a disease, which can be determined in skeletal remains. Therefore, based on the number of cases of TB and treponematosis in the Orendorf population, prevalence rates will be calculated and
subsequently compared with those for other prehistoric populations who show evidence of these diseases.

**Differential Diagnosis**

Differential diagnosis has not always been the preferred method to use when working with ancient materials. This technique essentially came into the forefront as a response to the “clinical approach” utilized in paleopathological research done prior to the 1970’s. In essence, the clinical approach is incomplete and self-limiting, with little regard for extensive descriptions of the pathology in question as well as diagnostic criteria. Also, it seldom speaks to the importance of demographics in making an accurate diagnosis, which is a hallmark feature in differential diagnosis (Buikstra and Cook 1980).

Differential diagnosis appears to be much more holistic than its predecessor in that it paints much more of an anthropological picture of the health of past populations than does the clinical approach. Characteristics of skeletal lesions are definitely taken into consideration, but other criteria such as demographics of the population, cultural factors, and geography play a significant role in determining the most plausible etiology for the skeletal pathology in question (Buikstra and Cook 1980; Schwartz 1995). Elimination of pathological candidates essentially occurs on two levels. First, certain diseases can be discarded based entirely upon their respective skeletal features. Next, if diagnosis cannot be made using only this diagnostic criteria, further exclusions are made via cultural and demographic characteristics of the disease (Buikstra and Cook 1980; Schwartz 1995).

It has been previously mentioned that a number of studies have utilized differential diagnosis as part of their methodology. For example, Buikstra (1976a) relied heavily on this
technique while investigating vertebral lesions in the Schild population, a prehistoric Mississippian sample from the lower Illinois River valley. When confronted with skeletal lesions that were similar to those seen in TB, certain pathological conditions were first ruled out based upon their various diagnostic criteria. She was able to reject a number of conditions, such as Scheuermann’s disease, osteitis deformans, actinomycosis, histoplasmosis, and sarcoidosis, as causes of the observed skeletal lesions since the specific markers expected for these diseases do not resemble those that would be expected with tuberculous infection. If a diagnosis could not be made through this process, then other factors such as cultural practices and demographics of the population were used (Buikstra 1976a). By doing so, she determined that blastomycosis and TB were the most likely candidates to have caused the skeletal lesions. Blastomycosis was eventually ruled out because it tends to exhibit a sex, age, and occupational bias, whereas TB does not (Buikstra 1976a).

**Differential Diagnosis as the Methodology**

The first step in this study is to establish a demographic profile for the Orendorf sample. This is accomplished through age and sex determination of all available adult skeletons in the sample according to currently accepted standards (Buikstra and Ubelaker 1994). This profile is subsequently compared to that previously completed by Steadman (1999), with a re-evaluation of any discrepancies. The remains are then carefully analyzed for any pathological lesions that resemble those characteristic markers of TB and treponematosis. If present, each lesion is thoroughly documented and described using those methods outlined in Buikstra and Ubelaker (1994). Next, photographs of these suspicious
lesions are taken using either a 35mm print film or digital camera. Finally, radiographs (X rays) are taken of these lesions in order to ascertain the presence of any helpful diagnostic criteria that cannot be seen macroscopically.

Once all of the questionable lesions have been recorded, individuals are put into one of two categories according to the type of lesions that they possess: possible and likely. Possible lesions are those that have skeletal alterations that are indicative of the diseases, but are still ambiguous enough to prevent further classification into the likely category. Lesions labeled as likely are those that probably fulfill the diagnostic criteria of TB and treponematosis to the exclusion of all others. Following this classification, attempts are then made to diagnose the correct disease process using differential diagnosis. The differential diagnosis for this particular study is based upon the principles presented in Table 2 (TB) and Table 3 (treponematosis). For this research project, the steps for differential diagnosis are as follows:

1. Determine which of those ambiguous skeletal lesions may be confused with TB or treponematosis.

2. Following the methodology presented by Buikstra (1976a) and Buikstra and Cook (1981), attempt to exclude those pathologies that do not fit the criteria for either TB or treponematosis with the standards presented in Table 1 and Table 2.

3. With this shortened list, again following Buikstra (1976a) and Buikstra and Cook (1981), consider various characteristics of the Orendorf population (cultural practices, demographics, etc.) in order to diagnose the responsible condition.

It is important to provide an element of validation to this study. This is accomplished by sending photos of the suspicious lesions to an individual who possesses extensive knowledge about paleopathology and is familiar with the skeletal changes manifested in TB
Table 2  Differential Diagnosis of Tuberculosis-Like Lesions. Based primarily on Buikstra (1976a), Buikstra and Cook (1981), and Aufderheide and Rodriguez-Martin (1998)

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>Specific Geographic Location</th>
<th>Primary Skeletal Focus/Foci</th>
<th>Excluding Diagnostic Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic Pyogenic Osteomyelitis</td>
<td>No specific geographic location</td>
<td>Long Bones</td>
<td>New bone formation occurs at a less advanced stage than in TB; larger sequestra; proliferation around margins</td>
</tr>
<tr>
<td>Brucella Osteomyelitis/Brucellosis</td>
<td>Important disease in agricultural countries of the Mediterranean (African and European), New Zealand, Asia, Central America, Mexico, and South America</td>
<td>Vertebrae</td>
<td>Paravertebral abscess formation is uncommon; low mortality rate among young adults; produces new bone formation, which is rare in TB</td>
</tr>
<tr>
<td>Coccidioidomycosis</td>
<td>Endemic to arid/semiarid regions of southwestern United States (Arizona, New Mexico, Texas, Nevada, Utah), Northern Mexico, Central America, South America (Argentina, Colombia, Bolivia, Venezuela), and even Europe</td>
<td>Small bones of hands and feet, spine, and ribs</td>
<td>Involves posterior elements of the spine, which is uncommon in TB</td>
</tr>
<tr>
<td>Healed Vertebral Fractures</td>
<td>No specific geographic location</td>
<td>Vertebrae</td>
<td>Usually only one vertebrae is involved; not as much destruction of the vertebral body; non-angular kyphosis; large, localized bony callus may be present</td>
</tr>
<tr>
<td>Pathological Condition</td>
<td>Specific Geographic Location</td>
<td>Primary Skeletal Focus/Foci</td>
<td>Excluding Diagnostic Criteria</td>
</tr>
<tr>
<td>------------------------</td>
<td>-----------------------------</td>
<td>-----------------------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Blastomycosis</td>
<td>Northeastern North America, Ohio/Mississippi Valley, Mid-Atlantic States, North/South Carolina, southern Manitoba, southwest Ontario, St. Lawrence River area, and Africa (Tunisia, Morocco, Congo, South Africa, Uganda, Rhodesia, Tanzania, Malagasy Republic)</td>
<td>Thoracic/lumbar vertebrae, ribs, tibia, tarsus, and carpus</td>
<td>Involves posterior elements of the spine; most often affects males 20-40 years of age, no such sex bias in TB; will involve the metaphyses of long bones when affected, spinal lesions are much smaller and are not as self-contained as in TB (Hershkovitz, et al. 1998)</td>
</tr>
<tr>
<td>Actinomycosis</td>
<td>Worldwide distribution</td>
<td>Mandible/maxilla</td>
<td>Mandible is the most frequently involved skeletal element; lesions on the neural arch are common</td>
</tr>
<tr>
<td>Echinococciasis</td>
<td>North America, Eastern Europe, Australia, New Zealand, and arctic areas</td>
<td>Lower vertebrae, pelvis, femur, humerus, tibia, and fibula</td>
<td>Less skeletal involvement than in TB; laminae and adjacent ribs are involved but vertebral body is not; low mortality rate among young adults</td>
</tr>
<tr>
<td>Histoplasmosis</td>
<td>North America (Ohio/Mississippi River valleys, northeastern United States), Central/South America, Africa (between Sahara and Kalihari), and southeast Asia</td>
<td>Skull, small bones of the hands and feet, radius: short, long, and flat bones</td>
<td>Vertebral involvement as well as skeletal lesions in general are uncommon</td>
</tr>
</tbody>
</table>
Table 2  Differential Diagnosis of Tuberculosis-Like Lesions, continued

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>Specific Geographic Location</th>
<th>Primary Skeletal Focus/Foci</th>
<th>Excluding Diagnostic Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malignant Bone Tumors</td>
<td>No specific geographic location</td>
<td>Affects all of skeleton except for the hand and foot bones</td>
<td>Usually involve more than two nonadjacent vertebrae as well as the neural arch and ribs; low mortality rate among young adults</td>
</tr>
<tr>
<td>Osteitis Deformans/Paget’s Disease</td>
<td>England, Europe, Australia, and New Zealand</td>
<td>Skull, spine, pelvis, and long bones</td>
<td>Do not include resorptive lytic foci; kyphosis due to compression fractures; vertebral lesions are generally rare; commonly in males over 40 years old (Ortner and Putschar 1981)</td>
</tr>
<tr>
<td>Rheumatoid Arthritis</td>
<td>No specific geographic location</td>
<td>Small joints of the hand/foot, knee, shoulder, elbow, wrist and the temporomandibular joint</td>
<td>Joint involvement is often bilateral; usually do not affect the thoraco-lumbar regions of the spine; females generally more affected than males</td>
</tr>
<tr>
<td>Scheuermann’s Disease</td>
<td>No specific geographic location</td>
<td>Vertebral bodies</td>
<td>Non-angular kyphosis; resorptive lesions are more rectangular than round</td>
</tr>
<tr>
<td>Septic arthritis</td>
<td>No specific geographic location</td>
<td>Affects all joints of the body (hip joint most common in children)</td>
<td>Process is more rapid but less destructive than TB</td>
</tr>
<tr>
<td>Spondylitis (Ankylosing)</td>
<td>No specific geographic location</td>
<td>Sacroiliac joint and spine</td>
<td>Involves anterior aspect of vertebral bodies; no lytic destruction</td>
</tr>
<tr>
<td>Pathological Condition</td>
<td>Specific Geographic Location</td>
<td>Primary Skeletal Focus/Foci</td>
<td>Excluding Diagnostic Criteria</td>
</tr>
<tr>
<td>----------------------------</td>
<td>------------------------------</td>
<td>-------------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Histiocytosis/Histiocytosis-X</td>
<td>No specific geographic location</td>
<td>Skull (frontal bone), mandible, humerus, ribs, spine (thoracic/lumbar), femur (diaphysis/metaphysis)</td>
<td>Vertebral involvement uncommon; cranial lesions usually do not have a central sequestrum and do not cross the cranial sutures</td>
</tr>
<tr>
<td>Sarcoidosis</td>
<td>No specific geographic location</td>
<td>Small bones of the hand</td>
<td>Vertebral involvement uncommon</td>
</tr>
<tr>
<td>Traumatic arthritis</td>
<td>No specific geographic location</td>
<td>Hip, knee, and ankle joints but any joint of the body can be afflicted</td>
<td>Usually occur with compression fractures in spine; do not involve resorptive lytic foci</td>
</tr>
</tbody>
</table>
Table 3  Differential Diagnosis of Treponematosis-Like Lesions. Based Primarily on Steinbock (1976) and Aufderheide and Rodriguez-Martin (1998)

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>Specific Geographic Location</th>
<th>Primary Skeletal Focus/Foci</th>
<th>Excluding Diagnostic Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leprosy</td>
<td>Worldwide distribution</td>
<td>Small bones of the face, hands, and lower leg bones</td>
<td>May produce similar lesions in the nasal and palatal bones but new bone formation on the long bones is rare</td>
</tr>
<tr>
<td>Meningioma</td>
<td>No specific geographic location</td>
<td>Skull</td>
<td>Is a tumor of the skull; no postcranial involvement</td>
</tr>
<tr>
<td>Metastatic carcinoma</td>
<td>No specific geographic location</td>
<td>Vertebrae, pelvis, ribs, major long bones, sternum, and skull</td>
<td>Cranial lesions are not completely necrotic and are smaller than those of syphilis; lesions are expansile and have little/no bone regeneration</td>
</tr>
<tr>
<td>Multiple Myeloma</td>
<td>No specific geographic location</td>
<td>Mandible, acromion, glenoid, olecranon, scapula, clavicle, radius, and ulna</td>
<td>Smaller cranial lesions that present little/no bone regeneration (see Metastatic Carcinoma); lesions are only lytic</td>
</tr>
<tr>
<td>Primary Osteogenic Sarcoma/Primary Osteosarcoma</td>
<td>No specific geographic location</td>
<td>Affects all of the skeleton except the hand and foot bones</td>
<td>Usually involves only one bone; skeletal syphilis most often is bilateral and in an older age group</td>
</tr>
<tr>
<td>Pyogenic Osteomyelitis</td>
<td>No specific geographic location</td>
<td>Long bones</td>
<td>Usually involves fewer bones than syphilis; produces sequestra and cloacae formation that is seldom seen in syphilis</td>
</tr>
</tbody>
</table>
Table 3  Differential Diagnosis of Treponematosis-Like Lesions, continued

<table>
<thead>
<tr>
<th>Pathological Condition</th>
<th>Specific Geographic Location</th>
<th>Primary Skeletal Focus/Foci</th>
<th>Excluding Diagnostic Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteitis Deformans/Paget’s Disease</td>
<td>England, Europe, Australia, and New Zealand</td>
<td>Skull, spine, pelvis, and long bones</td>
<td>Postcranial lesions are similar to those found in syphilis but the extensive thickening of the cranial vault is not present in syphilis; commonly in males over 40 years of age (Ortner and Putschar 1981)</td>
</tr>
<tr>
<td>Tuberculosis</td>
<td>Worldwide distribution</td>
<td>Spine, synovial joints, ribs, sternum, pelvis, and long bones</td>
<td>Differential diagnosis is difficult but TB shows little/no healing and no hypertrophy of the long bones; cranial lesions with TB begin at the inner table of the skull</td>
</tr>
<tr>
<td>Trauma</td>
<td>No specific geographic location</td>
<td>Any bone can be affected</td>
<td>Would see evidence of healing of a traumatic event, such as a bony callous</td>
</tr>
<tr>
<td>Non-specific periostitis</td>
<td>No specific geographic location</td>
<td>Any bone can be affected</td>
<td>Treponemal periosteal reactions tend to form on bones that are close to the skin surface (e.g. tibia, cranial bones) (Ortner and Putschar 1981)</td>
</tr>
</tbody>
</table>
and treponematosis. Further validation is provided by the researcher’s examination of pathological cases that are likely the result of the diseases in question. In September 1999, I traveled to Indiana University in Bloomington, Indiana, to examine some of the pathological cases in the Schild sample, under the direction of Dr. Della Cook, a leading authority in paleopathological research. This provides credibility to my aptitude in identifying those lesions that are indicative of TB and treponematosis.

It should also be noted that three other types of data are gathered while during examination of the Orendorf remains for skeletal evidence of TB and treponematosis. A tally of the number of individuals that exhibit spinal osteoarthritis is kept, as severe cases may manifest vertebral fusion that may be confused with TB. Another list is also generated that included individuals whose vertebral centra manifested small areas of microporosity that could also possible be indicative of TB, but do not show the characteristic large lytic lesions that would be expected (Baker 1999). Finally, the number of individuals that exhibited extensive excavation and taphonomic damage to the centra is also documented, as these changes can also be mistaken for tuberculous lesions or can inhibit proper examination of the remains.

Once the number of cases of TB and treponematosis has been determined, prevalence rates are computed using these figures and the formula presented in figure 3. In these calculations, the denominator is the number of individuals in the subsample (117) and not the number in the entire cemetery (284). For statistical analysis, chi-square tests are performed on the number of cases of these diseases in the Orendorf population in comparison to those seen in other prehistoric populations, again using 117 in these calculations. The
comparative populations used in regards to TB lesions are Schild (Buikstra 1976a; Buikstra and Cook 1981), Moundville (Powell 1988), and Norris Farms #36 (Milner and Smith 1990). Norris Farms #36 is also used as a comparative population for treponematosis.
CHAPTER SIX
RESULTS

The results of this study indicate that TB and treponematosis were present in chronic form in the Orendorf population. Out of the 117 individuals examined, there are 2 possible cases of TB, 4 possible cases of treponematosis, 1 likely case of TB, and 3 likely cases of treponematosis. Outlined in detail in this chapter are the results of the differential diagnosis that is applied to each of these cases. It will be seen that, especially with the possible cases, it is not feasible to eliminate some conditions that present similar skeletal alterations as the diseases in question. However, in these instances, it is not possible to rule out TB or treponematosis as well.

Also provided in this chapter are the results of the statistical tests run on the data, in addition to the number of individuals that exhibit taphonomic damage to the vertebrae, extensive porosity in the centra, and spinal osteoarthritis. Further, prevalence rates for the Orendorf sample are provided along with those from other Mississippian and non-Mississippian sites.

Burial 1: Possible Case of Treponematosis

Burial 1 is the relatively complete and well-preserved skeleton of a 45 to 50 year old male that presents as a possible case of treponematosis. On the distal end of the right tibia there is an area of bone formation that starts on the anterior shaft and continues laterally to the posterior shaft, but does not encircle it completely. The edges of the lesion are somewhat defined; there is some porosity and the lesion is slightly lighter in color than the surrounding bone (especially on the posterior/lateral aspect). At its greatest length, the lesion measures
73.83 mm (anterior/posterior). There is no “saber shin” deformity present. The distal shaft of the left tibia shows an area of expansion that, unlike the right tibia, encircles the entire bone. Overall, this lesion has healed, as evidenced by the lack of porosity and well-defined boundaries. Again, there is no midshaft involvement or “saber shin” deformity present.

Radiographs of both the right and left tibiae indicate increased periosteal bone deposition on the lateral aspect of the middle to distal diaphysis. In addition, the left tibia manifests a very slight increase in periosteal bone on the medial aspect of the middle to distal diaphysis as well. It appears that in both bones there may be some constriction of the medullary cavity due to a possible increase in cancellous bone. Also in the middle to distal shafts of both bones, there appears to be posterior cortical bone thickening. Radiographs further support the absence of a “saber shin” deformity.

The distal diaphysis of the left fibula also displays evidence of circumferential new bone formation. The majority of the lesion appears to be healed. However, there is a small area on the medial aspect that exhibits porosity. At its greatest length, the lesion measures 102.70 mm. Upon radiologic examination, it appears that there is periosteal thickening on the middle diaphysis that is at the same level as the lesion on the left tibia. There is a marked increase in cancellous bone deposition and subsequent medullary cavity constriction. No gross shape abnormality is noted. It should also be mentioned that there is no cranial involvement noted with Burial 1 that would be indicative of treponemal disease. However, the skull is very fragmentary, but is well preserved and relatively complete. Also, it must be noted that most of the face is missing postmortem, with no nasals, palate, or maxillary teeth.

With the use of differential diagnosis, it is possible to eliminate practically all of the pathologies that may be confused with treponematosis, with the exception of non-specific
periostitis. Leprosy is removed because new bone formation on long bones is rare. Meningioma is eliminated because it is exclusively a tumor of the skull and does not affect the postcranial skeleton in the same fashion as treponematosis (Aufderheide and Rodriguez-Martin 1998:163). Metastatic carcinoma is also eliminated because it is only confused with treponematosis when there are lytic lesions on the cranial vault (Aufderheide and Rodriguez-Martin 1998:163). Multiple myeloma has similar skeletal manifestations as metastatic carcinoma and is primarily lytic, whereas formation is the osteological response in Burial 1. Primary osteogenic sarcoma (primary osteosarcoma) usually only involves one bone, whereas skeletal treponematosis is most often bilateral. The sequestra and cloacae formation that customarily accompanies pyogenic osteomyelitis is absent in this case. Osteitis deformans (Paget’s disease) produces similar postcranial lesions to those seen in treponematosis; however, there is often marked thickening of the cranial vault with this disease that is not demonstrated in Burial 1. Further, even though this individual falls into the expected age range for osteitis deformans, radiographs of the affected elements reveal constriction of the medullary cavity. There is some debate in the literature regarding the role of medullary cavity constriction in osteitis deformans. According to Ortner and Putschar (1981), medullary cavity constriction is part of its disease process, while Cook (1979) and Aufderheide and Rodriguez-Martin (1998) disagree. Since there is a discrepancy involving this particular diagnostic characteristic, it will not be used as part of the differential diagnosis. However, it is possible to eliminate osteitis deformans due to the lack of cranial thickening in Burial 1 that would be expected. Tuberculosis is excluded as the cause of these skeletal lesions because it does not produce hypertrophy of the long bones that is exhibited in
this individual. It is not likely that a traumatic event caused the lesions in question, due to the absence of a fracture or a bony callous that would suggest healing.

Although it is feasible to eliminate most of the pathologies that could be confused with treponematosis, Burial 1 is still categorized as a possible case because it is not possible to rule out periostitis as the responsible disease process. However, the characteristics exhibited by this individual are ambiguous enough to prevent further classification in the likely category. For example, there is no “saber shin” deformity noted on the tibia and no cranial lesions that would be expected in treponemal disease. In addition, it is not possible to eliminate non specific periostitis as the cause for these lesions for these same reasons.

**Burial 25: Possible Case of Treponematosis**

Burial 25 is the relatively complete and well preserved skeleton of a 40-50 year old male with skeletal lesions that are suggestive of treponematosis. This individual exhibits periostitis throughout the postcranial skeleton. However, it is lesions on the upper and lower extremities that are of special interest. On the upper extremity, only the lesions on the right humerus, radius, and ulna will be discussed in detail, as these elements display much more periosteal involvement than their counterparts on the left. The right humerus has a small lesion on the posterior aspect of the diaphysis. It is brownish in color and shows very little porosity; the edges are still visible but are not very distinct. Measurements are 27.21 mm (superior/inferior) and 10.04 mm (medial/lateral). On the right radius, inferior to the radial tuberosity, there is an area of periosteal buildup that is brownish in color, but has little porosity and discernable edges. It measures 25.54 mm (superior/inferior) and 9.50 mm (medial/lateral). In addition, there is another lesion on the posterior portion of the diaphysis.
This lesion is porous, as well as thick and brownish-gray in color. It measures 50.36 mm (superior/inferior) and 13.72 mm (medial/lateral).

From a radiologic standpoint, these particular bones show changes that could be considered as consistent with treponemal disease. All show increased cortical thickening and medullary narrowing in the midshaft.

Overall, the lower extremities seem to have a much greater degree of periosteal involvement than the upper extremities. The right and left femora both manifest thick periosteal lesions throughout the diaphyses. These are a mixture of both active and sclerotic responses, as evidenced by grayish-brown color with varying amounts of porosity. On the right femur, only the proximal epiphysis and the distal diaphysis/epiphysis are spared. On the other hand, the only unaffected regions of the left femur are the proximal epiphysis and the anterior aspect of the distal diaphysis. In addition, the left femur displays an especially thick deposition of bone inferior to the head and anterior to the lesser trochanter. It measures 29.38 mm (superior/inferior) and 13.90 mm (anterior/posterior).

Like the femora, the right and left tibiae manifest extensive periosteal lesions throughout the diaphyses. The lesions are thick, especially near the distal aspects of the bones. Again, like the femora, these appear to be a mixture of active and sclerotic reactions. For the most part, distribution appears to be confined to the medial and lateral aspects of the shafts, with no anterior tibial crest involvement or “saber shin” deformity.

The right and left fibulae also display similar lesions to those seen on the femora and tibiae. Nearly the entire shaft is affected bilaterally with bone deposition that has a mixture of active and sclerotic properties. The only areas excluded from involvement are the proximal ends of the shafts.
When viewing the radiographs of the right upper extremity as well as the lower extremities of both sides, there are some visible changes that could be deemed as treponematosis. Radiographs of the right humerus demonstrate evidence of cortical thickening and marked cancellous bone growth in the middle diaphysis, while those of the right radius and ulna do not cancellous thickening in the medullary cavity. Both the right and left femora exhibit cortical thickening on the middle and proximal diaphysis with increased cancellous bone growth near midshaft. The tibiae also display similar radiographic findings with cortical thickening of the middle diaphyses and increased cancellous bone deposition in the medullary cavity. However, while the cortical thickening is remarkable, it may not be out of the range of normal variation. Finally, the left and right fibulae exhibit findings consistent with the other skeletal elements, i.e. thickened cortical bone and increased cancellous bone growth.

Like Burial 1, it is possible to eliminate the majority of the conditions that could be confused with treponematosis, again with the exception of non specific periostitis. In fact, the reasons for excluding these pathologies are fairly similar, but with some differences. Leprosy is eliminated because new bone formation is rare on the long bones. The lack of cranial involvement in Burial 25 excludes meningioma, as this is primarily a tumor of the skull and does not possess the same type of skeletal changes that would be expected for treponematosis (Aufderheide and Rodriguez-Martin 1998:163). Metastatic carcinoma becomes an issue when the focus of the skeletal lesions is in the skull (Aufderheide and Rodriguez-Martin 1998:163), which is not demonstrated on Burial 25. Since the lesions on Burial 25 are exclusively of a formative nature, it is possible to eliminate multiple myeloma. Primary osteogenic sarcoma (primary osteosarcoma) is excluded because it often only
involves one bone. There is no evidence of a cloaca or sequestrum that would suggest pyogenic osteomyelitis. The age of Burial 25 fits the demographic profile for osteitis deformans (Paget’s disease); however, there is no thickening of the cranial vault. Tuberculosis is excluded because of the marked hypertrophy of the long bones exhibited in this individual. Finally, there is no evidence of a traumatic event.

Burial 25 is classified as a possible case because of the ambiguous nature of the skeletal lesions (i.e. no saber shin deformity or destructive lesions of the face and palate). Therefore, it is not possible to definitively say that treponematosis is the responsible disease process. Also, it is not plausible to eliminate non specific periostitis as the cause of the lesions. Nearly every major long bone is affected, as well as the scapulae, some ribs, right os coxa, metacarpals, and feet. The mixed healing processes suggest that this was a chronic disease process that was still active at the time of death.

**Burial 30: Possible Case of Treponematosis**

Burial 30 is the relatively complete skeleton (minus the left os coxa) of a female, aged 15 to 20 years old at death. However, the cranium is very weathered and there is differential preservation throughout the skeleton. This individual has changes on the left tibia and both fibulae that present as a possible case of treponematosis. On the left tibia, at the anteromedial aspect of the middle diaphysis, there is a raised lesion of bone that is likely sclerotic in nature. The lesion is very localized margins, with somewhat visible margins, little to no porosity and is the same color as the surrounding bone. The lesion measures 36.28 mm (superior/inferior) and 17.01 mm (anterior/posterior). There is no “saber shin”
deformity present and from gross examination, the right tibia does not seem to have any abnormal periosteal bone growth.

The right and left fibulae manifest mixed lesions on the diaphyses of both bones. The left fibular lesion is concentrated more towards the shaft and appears to be thicker than its counterpart on the right, which is oriented more towards the distal shaft. However, on both sides, the lesions are circumferential. The edges are not visible, as they are incorporated into the surrounding bone. In addition, it is important to note that there is no characteristic craniofacial involvement noted on this individual. However, the inner surface of the vault has some taphonomic erosion, but is not lytic activity as would be expected in treponematosis.

Radiographs of the left tibia and left and right fibulae display increased spongy bone growth in the medullary cavity. This growth is more pronounced in the left tibia. The right tibia shows possible cancellous bone thickening in the medullary cavity and very minor cortical thickening.

The use of differential diagnosis on Burial 30 yields somewhat similar results as seen with Burials 1 and 25. Again, most of the confounding pathologies can be effectively rejected based on the following principles. Leprosy can be eliminated based upon the new bone formation on the long bones that is not a hallmark characteristic of this disease. Since meningioma is exclusively a tumor of the skull and does not affect the postcranial skeleton like treponematosis (Aufderheide and Rodriguez-Martin 1998:163), it can be ruled out. Metastatic carcinoma is excluded because it is only confused with treponematosis when there are cranial lesions (Aufderheide and Rodriguez-Martin 1998:163). The lack of lytic activity in these lesions eliminates multiple myeloma. The bilateral involvement of the lower limbs
rules out primary osteogenic sarcoma (primary osteosarcoma), which often affects only one bone. Pyogenic osteomyelitis is removed because Burial 30 does not present any evidence of a cloacae or sequestrum. The absence of cranial bone thickening eliminates osteitis deformans (Paget’s disease). In addition, since this individual is a female aged at 15-20 years old, they do not fit the demographic profile that would be expected for osteitis deformans. Tuberculosis is not likely the cause of these lesions since hypertrophy of the long bones is rare for that disease. Lastly, there is no skeletal evidence of trauma noted.

Burial 30 is still classified as a possible case of treponematosis, due to the lack of a “saber-shin” deformity, caries sicca, and nasal and palatal lesions. In addition, like Burials 1 and 25, non specific periostitis cannot be ruled out as a cause of these lesions. There are also periosteal lesions on the metatarsals of both feet that may further support either treponemal involvement or non specific periostitis.

**Burial 134: Possible Case of Treponematosis**

Burial 134 is a 25-35 year old female that is represented by a very poorly preserved, fragmentary and incomplete skeleton. However, there are skeletal changes on the left tibia that present as a possible case of treponematosis. This bone manifests bowing on the anterior shaft with marked periosteal deposition. The proximal epiphysis is missing due to postmortem damage, so it is somewhat difficult to assess the extent of the new formation. but overall, it does appear to be well remodeled and healed. It should be noted that due to this damage, it can be seen that the medullary cavity is completely occluded with cancellous bone in this area. There is a cloacae with a sequestrum on the proximolateral shaft, in the proximal metaphyseal region. There is a sharp ridge of bone (i.e. the sequestrum) that
measures 16.81 mm in length coming out of the cloacae and projects in a lateral direction. The edges of the cloacae seem to be healing. There is no craniofacial involvement noted, though the posterior vault is missing postmortem. Figure 7 is a photo of the left tibia.

Radiologic analysis demonstrates the presence of cancellous bone buildup in the proximal epiphysis and diaphysis with complete occlusion of the medullary cavity locally. In fact, this area is completely white on the radiograph due to the marked deposition of cancellous bone. Posterior cortical thickening is also evident, with continuation distally throughout the diaphysis. The cloacae and sequestrum manifest are visible radiologically on the proximal shaft, with visible cloacal “tracks.”

Burial 134 is different from Burials 1, 25, and 30 in that there is more than one condition that cannot be ruled out via differential diagnosis. The hallmark features of primary osteogenic sarcoma (primary osteosarcoma) and pyogenic osteomyelitis bear enough resemblance to those of treponematosis, that it is arduous to pinpoint the exact cause for the lesions displayed on Burial 134. Also, it is possible that some sort of traumatic event contributed to these lesions.

The excluding criteria for the pathologies that can be confused with treponematosis are relatively the same as those utilized for the other possible cases. Leprosy can be eliminated because new bone formation on the long bones is an uncommon occurrence in this disease. Meningioma is not a likely cause for these lesions because it is chiefly a tumor of the skull and does not manifest the same alterations on the postcranial skeleton as those expected for treponematosis (Aufderheide and Rodriguez-Martin 1998:163). Multiple myeloma is excluded because these lesions are primarily lytic; in Burial 134 there are mainly formative processes. Osteitis deformans (Paget’s disease) is eliminated due to the lack of
Figure 7 Burial 134, left tibia. Note cloacae and sequestrum on proximal end.
cranial bone thickening. Further, the age and sex of this individual (female, 25-35 years old) does not fit the expected age for osteitis deformans. Tuberculosis does not produce the hypertrophy of the long bones that is demonstrated in this individual. Finally, non specific periostitis can probably be removed because it does not produce either a cloacae or the abnormal bowed shape on this bone.

Primary osteogenic sarcoma (primary osteosarcoma) and pyogenic osteomyelitis are still considered because they predominately only affect one bone, which is the same as Burial 134. A defining characteristic of pyogenic osteomyelitis is the presence of a cloacae and sequestrum; a classic example of these are apparent on Burial 134. However, the attribute that keeps treponematosis as a viable cause for the lesions is the presence of bowing on the anterior tibial shaft that is often indicative of treponematosis. Aufderheide and Rodriguez-Martin (1998) as well as Ortner and Putschar (1981) do not discuss bowing as a potential manifestation in either primary osteogenic sarcoma (primary osteosarcoma) or pyogenic osteomyelitis. Also, the characteristics of the skeletal lesions expected for primary osteogenic sarcoma (primary osteosarcoma) are an “onion skin” appearance (on radiographs), an irregular surface, or bony spicules that arise from the cortex (Aufderheide and Rodriguez-Martin 1998:378), none of which are displayed in this burial. In addition, it should be noted that it is not possible to definitively rule out trauma as the ultimate cause of these lesions.

**Burial 55: Likely Case of Treponematosis**

Burial 55 is a relatively complete and well preserved skeleton of 20-30 year old female with skeletal lesions on the lower extremities that are likely consistent with
treponemal disease. On the midshaft of the right tibia, there is an active lesion that is especially conspicuous on the lateral aspect. However, on the medial aspect it appears to be slightly more healed. In addition, the medial aspect has some nodules that are difficult to discern macroscopically, but an irregular surface can be felt upon palpation of the periosteal surface. No “saber shin” deformity is noted. The diaphysis of the left tibia has an area of bone formation that has properties that appear to be a mixture of active and sclerotic reactions. Like its counterpart on the right, there is more woven bone on the lateral portion, with the medial aspect again demonstrating the same irregular topography. Further, there seems to be some slight periosteal buildup on the anterior tibial crest, which could be indicative of a “saber shin.” Figure 8 is a photo of the left tibia. The right fibula displays expansion of the distal diaphysis, with the same kind of irregular surface as seen on the tibiae but has some woven bone on the anteromedial aspect. The left fibula is not affected.

Examination of radiographs reveals osteological alterations that support treponematosis as a likely cause for these lesions. The left tibia shows posterior cortical thickening with periosteal deposition on the anterior shaft. There is also some increased cancellous bone growth in the medullary cavity in this particular portion of the bone that is viewed radiologically. Overall, the left tibia demonstrates an almost “bowed” morphology, although this is not exaggerated. Based upon comparisons with radiographs of a case of treponematosis published in Ortner and Putschar (1981:181), it is felt that this is most likely a saber shin morphology consistent with treponematosis. The right tibia also displays posterior cortical thickening in the same area as the left, but not to the same extent. Further, there is some increase in cancellous bone growth in this area, but again, not to the same degree as on
Figure 8 Burial 55, left tibia. Note periosteal deposition on anterior tibial crest.
the left. The anterior tibial crest has little to no periosteal bone deposition and there appears to be no abnormality in overall shape.

The right fibula shows some expansion of the middle diaphysis with some increase in periosteal bone deposition. The changes within the medullary cavity resemble those of the left tibia. In addition, there are no craniofacial lesions on this individual that could be attributed to treponemal involvement.

Since this Burial 55 is classified as a likely case, differential diagnosis is not exactly the same as that used for the possible cases. It is possible to remove the confounding pathologies in basically the same manner as the other cases, but in this instance, there is no pathology that cannot be excluded. Leprosy can be removed because it does not generally produce new bone formation on long bones. Meningioma is again eliminated because it is often a tumor of the skull and does not affect the postcranial skeleton in the same fashion as treponematosis (Aufderheide and Rodriguez-Martin 1998:163). Since there are no cranial lesions displayed on Burial 55, metastatic carcinoma can be excluded, as it is only confused with treponematosis when there is cranial involvement (Aufderheide and Rodriguez-Martin 1998:163). Primary osteogenic sarcoma (primary osteosarcoma) can be eliminated because more than one bone is affected by this pathology. The absence of a cloaca and sequestrum removes pyogenic osteomyelitis. Osteitis deformans (Paget’s disease) is removed due to the absence of cranial thickening. Further, since Burial 55 is a female aged at 20-30 years old, they are not part of the age and sex range expected for this disease. Tuberculosis is not a possibility because it does not produce the hypertrophy of long bones that is seen with Burial 55. There are no fractures or other evidence of a traumatic event. Finally, non specific periostitis is highly unlikely because in this instance, occlusion of the medullary cavity
accompanies the periosteal lesions that would not be expected if non specific periostitis was the cause of the lesions.

In summary, Burial 55 is considered as a likely case because of the bowing and posterior cortical thickening of the left tibia that, when compared to a case of treponemal involvement presented in the literature (Ortner and Putshcar 1981:181), exhibits the same overall morphology. Also, both of the clavicles display some sclerotic periosteal deposition and abnormal curvature on the lateral ends. This is of interest because the clavicles are common sites of nongummatous periosteal lesions that may suggest treponematosis (Aufderheide and Rodriguez-Martin 1998; Ortner and Putschar 1981).

**Burial 62: Likely Case of Treponematosis**

Burial 62 is the very fragmentary and poorly preserved remains of an adult, tentatively aged to 35-50 years old. Due to the fragmentary and incomplete nature of the skeleton, a sex estimate is not feasible for this individual. However, the lower extremities do show suspicious lesions that are consistent with treponematosis. The distal diaphyses of both the right and left femora have a great deal of lamellar bone that is concentrated primarily on the anterior aspect. This formation is quite pronounced and rises above the normal periosteal surface of the bone. However, the right side appears to be more affected than the left. On the right femur, just superior to the affected area on the right femur, there is postmortem damage to the bone that allows for direct examination of the medullary cavity. There is increased cancellous bone growth that occludes the medullary cavity. The extent is further investigated via radiologic examination, which will be addressed momentarily.
The total diaphysis of the right tibia has lamellar bone that is centered more on the anterior, versus the posterior, aspect. As with the femora, this formation is very pronounced and appears to involve the endosteum. There is a “saber shin” deformity. In addition, the medullary cavity is quite constricted by much cancellous bone growth. The left tibia has the same form of lamellar bone deposition as on the right, but not to the same extent. There is no real “saber shin” deformity, though the medullary cavity is still affected in the same manner.

Almost the entire diaphysis of the right fibula demonstrates roughened, circumferential lamellar bone. It is difficult to determine if the roughened appearance is the result of a taphonomic erosion or pathological process. Due to the marked deposition of periosteal bone, the right fibula is nearly 2-3 times its normal circumference. Again, the endosteal surface seems to be affected with the same type of marked cancellous bone growth and subsequent medullary cavity constriction. It is noteworthy to mention that the left fibula does not appear to be affected to the same degree as the right, although the left bone is incomplete.

Radiographs of the left and right femora show expansion of the distal one-third of the diaphysis. Consistent with macroscopic examination, there appears to be much cancellous bone growth in this area with constriction of the medullary cavity. Both the right and left tibiae demonstrate a large amount of diaphyseal expansion and periosteal bone deposition. From the radiographs (like the gross analysis), it appears that there is much cancellous bone growth in these areas, thereby practically obliterating the normal medullary space. In addition, both bones exhibit thickening of the cortical bone on the posterior aspect, although it is slightly more pronounced on the right. Finally, the right fibula demonstrates similar diaphyseal expansion as the tibiae. However, the lightened condition of the X ray makes it
difficult to determine much more detail. Due to the lack of cranial remains, it is impossible to determine the presence of craniofacial lesions.

The relative incomplete nature of the remains complicates the diagnosis of these skeletal lesions. However, those elements that are present are fairly convincing of treponemal involvement. Practically all of the lower limbs demonstrate marked periosteeal deposition and expansion that is seen so often in treponematosis. The presence of a definite “saber shin” deformity, in tandem with the almost complete occlusion of the medullary cavities of these bones points to treponemal involvement. Again, the same principles used for Burial 55 and the possible cases are used in the differential diagnosis of Burial 62, even with the lack of cranial remains. Leprosy can be ruled out because bone formation on the long bones is rare, which is demonstrated on Burial 62. It is a little more difficult to eliminate meningioma and osteitis deformans (Paget’s disease) due to the absence of cranial elements. However, osteitis deformans (Paget’s disease) can be eliminated due to the presence of a marked “saber shin” morphology; meningioma is not a likely candidate due to its lack of postcranial involvement. Metastatic carcinoma is only confused with treponematosis when the cranial bones are affected. However, with the lack of these bones, it is necessary to determine other characteristics of this disease that would help to differentiate it from treponematosis. The apparent focus of the lesions in Burial 62 is the distal diaphyses of the femora as well as the lower legs. Metastatic carcinoma usually affects the skull, sternum, proximal end of the femur, ribs and pelvis. Even though the proximal femora are missing postmortem, it is rare for this disease to strike the lower legs (Steinbock 1976:385), which is manifested in Burial 62. Multiple myeloma can be eliminated because its lesions are primarily lytic, none of which are seen on this individual. Since more than one
bone is stricken by these lesions, primary osteogenic sarcoma (primary osteosarcoma) and pyogenic osteomyelitis can be omitted. The expansion of the long bones rules out TB and there is no skeletal evidence of trauma. The presence of a “saber shin” deformity and complete occlusion of the medullary cavity suggests that non specific periostitis is not the cause of the skeletal changes seen on Burial 62.

Burial 136: Likely Case of Treponematosis

Burial 136 is the very incomplete and poorly preserved skeleton of a 40-50 year old male with skeletal lesions on both tibiae and the right fibula that are highly consistent with treponemal disease. The anterior aspects of both tibiae demonstrate sclerotic periosteal formation, but the left appears to be much less affected. In fact, the left tibia only has slight anterior bowing (possibly due to the periostitis) while the right has a large amount of bony formation that is quite distinct. On the right tibia, the medial aspect of the lesion has a more smooth appearance than the lateral, which is definitely roughened. As a result of postmortem damage, the epiphysis of this bone is missing, thereby exposing the medullary cavity. It can therefore be seen that the medullary cavity is occluded by cancellous bone. Further, the right tibia has three circular areas of bone loss that are likely attributed to postmortem damage. There are no cloacae noted on either tibia. The right fibula manifests sclerotic, roughened, and fairly extreme periosteal thickening on the middle diaphysis that is circumferential, while the left is unaffected. There are no cloacae present on the right fibula. In addition, there are no lesions on the craniofacial bones.

Radiographs were taken only of the right tibia and fibula. The right tibia showed definite periosteal bone deposition on the anterior shaft, with slight cortical bone thickening
on the posterior diaphysis. Further, there is increased cancellous bone growth and medullary cavity constriction in this area. The expansion of the right fibular shaft is apparent upon radiologic examination, as well as buildup of cancellous bone throughout the medullary cavity.

Differential diagnosis is able to effectively omit the pathologies that show similar skeletal characteristics as treponematosis. Leprosy can be excluded because it does not cause new bone formation on the long bones. Even though a great deal of the cranium is missing, it is possible to eliminate meningioma, as this pathology does not affect the postcranial elements as would be expected for treponemal disease. The lack of lesions on the available craniofacial elements rules out multiple myeloma; also, the formative processes on the lower leg bones of Burial 136 is the opposite of the lytic lesions that would be seen in multiple myeloma. The involvement of more than one bone omits primary osteogenic sarcoma (primary osteosarcoma); the nonexistence of a cloacae and sequestrum suggests that pyogenic osteomyelitis is not the responsible disease process. The lack of thickening of the available cranial elements excludes osteitis deformans (Paget’s disease). Tuberculosis does not produce hypertrophy of the long bones, as seen in Burial 136. There is also no evidence of any sort of traumatic circumstance. The constriction of the medullary cavities could potentially eliminate non specific periostitis.

Burial 136 is considered as a likely case of treponematosis because the right tibia displays much periosteal buildup in addition to the slight anterior bowing manifested on the left. Also, the right tibia shows some slight posterior cortical thickening and medullary cavity constriction that one would anticipate with treponemal disease.
Burial 85: Possible Case of TB

Burial 85 is the relatively complete skeleton of a 25-35 year old female with vertebral lesions that may have possible tubercular changes. The third lumbar vertebrae (L3) exhibits compression of practically the entire centrum. Figure 9 is a photo of L3. The only articulation with L4 is a small projection of bone located on the left posterolateral aspect of L3. Figure 10 is a photo illustrating the articulation of L3 and L4. There are also two small circular shaped lesions of bone loss on the superior ring with associated curled osteophyte formation on the rim. The first is on the posterior aspect of the superior surface. The edges are rough and it is difficult to determine if this is part of the pathology or due to taphonomy. The other lesion is located on the anterior aspect of the superior ring. It has smooth and sclerotic edges. It is important to note that there are no signs of fusion with either L2 or L4.

The superior centrum of L4 displays much bone loss that extends inferiorly into the cancellous bone. There are several foci of bone loss with some healing apparent, but the healing processes were mostly likely still occurring at the time of death. There is also a circular area of bone loss on the anterosuperior aspect of the centrum with what appears to be an osteophyte just lateral to it. On the posterior centrum, just medial to the lamina, there are two circular shaped defects that perforate anteriorly into the cancellous bone. The edges appear to be sclerotic but do not have any reactive bone formation. When looking inferiorly into the centrum through the lesion on the on the superior surface of the centrum, it can be seen that there are circular shaped lytic foci within the cancellous bone. There is no apparent reactive bone noted on these foci. In addition, no central canal expansion is manifested.
Figure 10 Burial 85, L3 and L4 (anterior view).
The superior articular facets of L4 appear to extend slightly posterior and likely accommodate the dislocation of the inferior articular facets of L3. This could be due to the consequences of the compression of the L3 centrum or is evidence of a traumatic event.

The use of differential diagnosis is able to rule out all but two of the confounding pathologies. If pyogenic osteomyelitis was the responsible disease process, proliferation around the margins of the lytic foci would be demonstrated, which is not seen on Burial 85. Brucellosis produces new bone formation, which in general, is rare in TB and is not manifested in this instance. Coccidioidomycosis produces lesions that are confined to the posterior elements of the spine; in Burial 85, the pathological involvement is restricted to the anterior portion. Blastomycosis can be omitted because its lesions are not as self-contained as in TB and also because it exhibits a sex bias; males that are 20-40 years of age are frequently targeted. Burial 85 is a female, aged 25-35 years. A healed vertebral fracture is likely not the cause of the destruction, as it usually only involves one vertebrae, while two are affected here. There is also no evidence of a bony callous that would indicate a healed fracture. Actinomycosis and histoplasmosis can be ruled out due to their overall lack of skeletal involvement. Histiocytosis (histiocytosis-X), osteitis deformans (Paget’s disease), and sarcoidosis are excluded because overall, vertebral lesions are uncommon. Echinococciasis includes pathological changes on the lamina and adjacent ribs, none of which are seen here. Two nonadjacent vertebrae are the primary foci of malignant bone tumors; this can be eliminated because the lesions on Burial 85 are restricted to two adjacent vertebrae. Rheumatoid arthritis customarily does not affect the thoracic and lumbar regions of the spine. Lesions of Scheurmann’s disease are rectangular shaped, those in Burial 85 are
round. Spondylitis (ankylosing) does include compression of the anterior aspect of the centra, but does not demonstrate any type of lytic involvement, as seen here.

The two conditions that could not be ruled out as the cause of the lesions seen in this individual are septic arthritis and traumatic arthritis. Both of these can produce compression of the centrum that is similar in nature to that on L3 and can appear to be as destructive as TB. However, there is not normally any lytic foci in these diseases. Even though there is not complete anterior collapse of L3, Burial 85 continues to be classified as a possible case, due to the presence of compression and lytic activity.

**Burial 105: Possible Case of TB**

Burial 105 is the relatively complete skeleton of a 15-20 year old male with suspicious-looking porotic lesions of practically the entire vertebral column. For the most part, these lesions are circular shaped and larger than what would be expected with normal variation of the vascular foramina. Throughout this discussion, each vertebrae will be identified by its region (i.e. cervical, thoracic, lumbar) and by its specific number, as done in the last section. Therefore, the first cervical vertebrae will be labeled as C1, the first thoracic as T1, and so forth.

The only cervical vertebrae that appear to be affected by this abnormal-looking porosity are C6 and C7. The porosity is concentrated on the right and left anterior centrum on C6 and on the right anterior centrum on C7. Also, the porosity on C7 is larger than that seen on C6.

A number of thoracic vertebrae are afflicted with the same type of porotic lesions manifested in the cervical vertebrae. However, the lateral portions are affected more in these
bones than in the cervical region. The extent of involvement in this region of the spine is from T2-T12, with T1 as the lone unaffected thoracic vertebrae. Figure 11 is a photo of the thoracic vertebrae.

Most of the lumbar region is affected as well, with L1 and L3-L5 exhibiting the same type of porotic activity displayed in the cervical and thoracic regions. It appears that these changes are concentrated on the anterior and lateral centrum. However, these vertebrae have suffered a great deal of taphonomic erosion, so it is difficult to assess the full extent of the involvement. In fact, most of the centrum of L2 is eroded away, so it is not possible to determine if this element contained the same type of porosity. Figure 12 is a photo of the lumbar vertebrae.

In summary, it can be said that a majority of the spine is subjected to some type of porotic activity that appears to be directed in the thoracic and lumbar regions, rather than the cervical. Some of these foci seem to involve the spongy bone of the centra, as well as the periosteal surface. There is not any evidence of bony response to these lesions and the posterior elements of the vertebrae are spared from the activity. In addition, there is much erosion in the thoracic and lumbar sections, with the lumbar being much more severely stricken. This makes it difficult to conclude if the porosity is due to a disease process or just to taphonomy. The edges of the porotic lesions are not white, as would be expected with excavation damage. In addition, a study conducted by Baker (1999) presents cases of vertebral porosity that is believed to be initial expressions of tuberculous activity prior to collapse.

There are also some changes outside of the spine that could possibly be associated with those seen in the vertebral column. For example, the right and left auricular surfaces
Figure 11 Burial 105, thoracic vertebrae. Note circular-shaped lytic foci on centra.
Figure 12 Burial 105, lumbar vertebrae. Note circular-shaped lytic foci on centra.
both manifest circular-shaped lytic foci that appear to perforate the cortex. The edges of these lesions are smooth, with no accompanying bony formation, although the sacro-iliac joint does not seem to be affected. Also, there is a small lytic focus on the sacrum, between the spinous processes of S1 and S2. Again, the edges are smooth and there is no reactive bone present. Finally, the left sacrum and the left auricular surface have some interesting skeletal modifications that are not seen on the right side. There appears to be the formation of an “accessory” facet or joint that is located posterior to the S1/S2 junction and the ala on the sacrum and on the posterior aspect of the auricular surface. This may just be a normal anomaly with no real pathological significance. However, since there is some type of lytic activity on the auricular surface, this facet may have formed to provide stability to the joint.

Chronic pyogenic osteomyelitis can be removed as a possible cause for these changes because there is no bone formation or proliferation around the margins of the porosity. The same is true for brucellosis, which will exhibit bone formation in response to lytic activity. Coccidioidomycosis and blastomycosis can be eliminated because these diseases commonly involve posterior aspects of the spine, which is not seen in Burial 105. Since there are more than one vertebrae affected, healed vertebral fractures can be excluded. Actinomycosis and histoplasmosis are not likely causes, as osseous involvement in general is rare for these pathologies. Histiocytosis (Histiocytosis-X), osteitis deformans (Paget’s disease), and sarcodiosis do not usually produce vertebral lesions. Echinococciasis does not customarily affect the centra. Malignant bone tumors are eliminated due to the fact that nonadjacent vertebrae are involved; in this case, a number of adjacent vertebrae show suspicious lesions. Rheumatoid arthritis does not often act upon the thoracic and lumbar regions of the spine. Resorptive lesions of Scheuermann’s disease have a more rectangular morphology; the
lesions displayed in Burial 105 are circular shaped. The lack of arthritic activity and compression fractures eliminates septic and traumatic arthritis. Finally, ankylosing spondylitis does involve the anterior portions of the centra, but not in a lytic fashion.

To reiterate a previous point, the lytic-looking activity demonstrated on this individual can be thought of as early manifestations of TB, when comparing to those cases presented in Baker (1999). The changes on the auricular surface and the sacrum also suggest a possible diagnosis of TB. However, without any evidence of anterior collapse of the vertebral column, it cannot be determined with certainty that this is indeed a case of TB. Further, it is very difficult to determine if the erosion presented in the thoracic and lumbar spine is due to a disease process or taphonomy. Therefore, it is for these reasons that Burial 105 is categorized as a possible case.

**Burial 153: Likely Case of TB**

Burial 153 is the well-preserved partial skeleton of a 40-45 year old male that demonstrates some interesting spinal pathology that appears to be consistent with skeletal TB. The vertebral column is extremely fragmentary. There is an extra thoracic vertebrae, making a total of thirteen thoracic vertebrae. There is also an additional rib, bringing that total to thirteen ribs. It is unknown if this is a bilateral occurrence.

Only the neural arch and the superoposterior aspect of the centrum are available for T12, as the rest of this skeletal element is missing postmortem. When viewing this vertebrae from the posterior angle, it seems that there may be some central canal expansion, as the superior portion of the canal seems to be enlarged. Unfortunately, the inferior part is missing postmortem. There are also some lytic foci just superior to both inferior articular facets and
on the posterior body, just inferior to the rib facet. Finally, there is a circular shaped depression on the superior centrum.

The remains of T13 are relatively fragmentary. The anterolateral aspect of the centrum has two side-by-side circular defects. It is difficult to assess whether these lesions originate within the centrum and expanded outwards, or vice versa. The edges of these lesions are smooth, with no accompanying color change, indicating that these alterations are not the result of postmortem damage. Figure 13 is a photo of T13, showing a close up view of these lesions. The most anterior lesion measures 7.18 mm by 3.92 mm. The most posterior lesion measures 5.85 mm (superior/inferior). An anterior/posterior measurement is not possible due to possible postmortem damage to the actual lesion. Within the centrum itself, near the anterior aspect, there is another circular shaped lesion that is present within the trabecular bone and does not extend to the outer portion of the bone. This lesion is filled with dirt from interment and I am unable to clean it out without damaging the remains. Therefore, it is not possible to make any further observations. There is also lytic expansion on the posterior body that extends into the cancellous bone of the centrum. The inferior portion of this vertebrae is missing postmortem, so I cannot determine if this activity is due to central canal expansion. Finally, there is a large, round lytic lesion on the right side of the vertebrae, just posterior to the lamina and on the opposite side of the right superior articular facet. It expands posteriorly into the neural arch and is located just superior to the inferior articular facet. Measurements of the lesion are 9.47 mm by 8.79 mm. Like the aforementioned lesion, it is also tightly packed with dirt and I am unable to determine any
Figure 13 Burial 153, T13 (anterolateral view). Note circular-shaped lesions on centrum.
further characteristics. Just superior to this lesion is another circular area of bone loss that manifests smooth edges. It measures 10.14 mm by 6.03 mm. Within this lesion is another lytic focus that measures 3.11 mm by 3.95 mm.

The centrum of L1 manifests a circular defect on the superolateral aspect of the posterior surface. It is just superolateral to the central canal and perforates the centrum itself, but does not continue deep within the cancellous bone. It measures 13.26 mm by 12.72 mm. There is no reactive bone formation noted and the edges of the lesion appear to be smoothed over on the posterosuperior aspect only. In addition, the actual central canal does not seem to be affected. Also, on the superior surface of the centrum there is a small lytic focus that is continuous with the large lesion on the posterior centrum that was just detailed. In addition, on the superior surface of the centrum there are some defects that may be Schmorl's nodes.

Several ribs also demonstrate skeletal changes that could support a diagnosis of TB. The internal aspect of what is believed to be left rib eleven shows a small area of mixed sclerotic and woven bone formation that is located near the neck. This lesion is not completely remodeled into the surrounding bone, as a piece of the lesion has broken off, revealing the underlying cortex. A number of miscellaneous rib fragments manifest scattered areas of sclerotic bone formation on the internal aspect of the middle shaft. These areas are grayish in color and contain very little visible porosity.

Differential diagnosis is able to eliminate all of the conditions that display similar skeletal lesions as those in TB. Chronic osteomyelitis is eliminated due to the lack of proliferation around the margins of the lytic activity. Brucellosis can be excluded for the same basic reason, as there is not bone formation in response to these lesions. Coccidioidomycosis is generally confined to the posterior elements of the spine, while this is
manifested in Burial 153, there is also pathologic changes in the anterior vertebrae that would not indicate coccidioidomycosis. While this individual does somewhat fit the demographic profile expected for blastomycosis, tuberculous lesions are more self contained as would be anticipated if blastomycosis was the cause. The absence of evidence for a fracture removes healed vertebral fractures; the lack of arthritic changes remove septic and traumatic arthritis. Since osseous involvement is rare in actinomycosis and histoplasmosis are not likely candidates. Histiocytosis (histiocytosis-X), osteitis deformans (Paget’s disease), and sarcoidosis do not commonly display vertebral lesions. Echinococciasis can be eliminated because centra involvement is not part of its disease process. Malignant bone tumors include more than two nonadjacent vertebrae, while Burial 153 involves 3 adjacent elements. Rheumatoid arthritis does not affect the thoracic and lumbar spine, where the lesions on this individual are evident. The circular shape of the lytic foci effectively excluded Scheuermann’s disease. Finally, ankylosing spondylitis does affect the anterior aspect of vertebrae, but will not demonstrate any lytic-appearing processes.

Burial 153 is classified as a likely case of TB because of the lytic nature of the lesions in the centra. While there is some pathologic activity in the posterior elements of the vertebrae, it is felt that the changes on the anterior centra are more diagnostically important. Periosteal deposition on the internal aspect of some ribs contributes to the belief that this is likely TB, based upon the work of Kelley and Micozzi (1984).

**Taphonomic Damage, Porosity, and Osteoarthritis**

It was mentioned in the preceding chapter that other types of data is collected in addition to tallying the number of cases of TB and treponematosis. These include: the
number of individuals that display extensive taphonomic and excavation damage to the vertebrae, microporosity in the vertebral centra, and spinal osteoarthritis. Each of these manifestations can be mistaken for tuberculous lesions. However, with taphonomic and excavation damage as well as osteoarthritis, it is confused usually in the extreme instances. It is discovered that out of 117 individuals, there are 22 (18.8%) that exhibited taphonomic and excavation damage in the vertebral column. Porosity in the centra is displayed in 20 individuals (17.1%), while 41 (35%) demonstrated evidence of spinal osteoarthritis.

**Statistical Analysis**

In order to determine if the number of cases of TB and treponematosis in the Orendorf population is comparable to those seen in other prehistoric sites, a Chi-square analysis is performed. For TB, the figures from Orendorf are compared to three other sites, the Schild site from the lower Illinois valley (Buikstra 1976a; Buikstra and Cook 1981), Moundville from the southeastern United States (Powell 1988), and Norris Farms #36 from Illinois (Milner and Smith 1990). However, it should be noted here that the Schild figures include 1 juvenile case; for that particular study, individuals 10 years and up were included in the sample (Buikstra 1976a; Buikstra and Cook 1981). There is no way to determine the number of 10-15 year olds in that sample based upon the manner in which the demographic profile is presented. However, since there is only 1 case of juvenile TB in the Schild study and the age criteria is fairly similar to that in the current investigation, the data is comparable. Also, it is important to know that the Schild and Moundville sites are from the Mississippian cultural tradition, while Norris Farms #36 (A.D. ~1300) is part of the Oneota tradition, which
Table 4 Contingency table for Chi-square analysis and prevalence rates of TB cases

<table>
<thead>
<tr>
<th>Site</th>
<th>Affected</th>
<th>Not Affected</th>
<th>Prevalence Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schild</td>
<td>12</td>
<td>163</td>
<td>6.9%</td>
</tr>
<tr>
<td>Moundville</td>
<td>11</td>
<td>413</td>
<td>6.0%</td>
</tr>
<tr>
<td>Norris Farms #36</td>
<td>21</td>
<td>232</td>
<td>8.3%</td>
</tr>
<tr>
<td>Orendorf</td>
<td>3</td>
<td>114</td>
<td>2.6%</td>
</tr>
</tbody>
</table>

Table 5 Results of Chi-square analysis by site for TB cases

<table>
<thead>
<tr>
<th>Site</th>
<th>$\chi^2$ Value</th>
<th>p value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schild (12/175)</td>
<td>2.654</td>
<td>0.103</td>
<td>Not significant</td>
</tr>
<tr>
<td>Moundville (11/424)</td>
<td>0.000393</td>
<td>0.985</td>
<td>Not significant</td>
</tr>
<tr>
<td>Norris Farms #36</td>
<td>4.339</td>
<td>0.037</td>
<td>Significant</td>
</tr>
</tbody>
</table>

Critical value 3.84 when $\alpha=0.05$ and 1 degree of freedom

follows the Mississippian. The contingency table for the Chi-square analysis, as well as the prevalence rates for TB, is presented in Table 4, while the results of the statistical analysis are offered in Table 5. It should also be noted here that for Orendorf, the total number affected is the sum of the possible and likely cases. There are 3 individuals affected with TB (2 possible, 1 likely), while there are 7 affected with treponematosis (4 possible, 3 likely).

For treponematosis, the results from Orendorf are compared with only one site, Norris Farms #36 (Milner and Smith 1990). Comparative data from other sites is difficult to locate, as the results from these studies are presented in ways that do not coincide with the current investigation. The data from these examinations are expressed in terms of numbers of elements affected, rather than in a case-by-case manner. The problems with communicating data in this way will be dealt with in the following chapter. The contingency table for the Chi-square analysis, as well as the prevalence rates for treponematosis, is presented in Table 6, while the results of the statistical analysis are given in Table 7.
Table 6  Contingency table for Chi-square analysis and prevalence rates of treponematosis cases

<table>
<thead>
<tr>
<th>Site</th>
<th>Affected</th>
<th>Not Affected</th>
<th>Prevalence Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norris Farms #36</td>
<td>10</td>
<td>243</td>
<td>4.0%</td>
</tr>
<tr>
<td>Orendorf</td>
<td>7</td>
<td>110</td>
<td>6.0%</td>
</tr>
</tbody>
</table>

Table 7  Results of Chi-square analysis by site for treponematosis cases

<table>
<thead>
<tr>
<th>Site</th>
<th>$\chi^2$ Value</th>
<th>p value</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norris Farms (10/253)</td>
<td>0.753</td>
<td>0.389</td>
<td>Not significant</td>
</tr>
</tbody>
</table>

Critical value 3.84 when $\alpha=0.05$ and 1 degree of freedom

Concluding Remarks

There is much insight to be gained from the information that was presented in this chapter. The implications of this information in relation to Orendorf as well as other prehistoric populations will be addressed in more detail in the following chapter.
CHAPTER SEVEN
DISCUSSION AND CONCLUSION

The results of this study provide support for the hypothesis that this sample of the adult Orendorf population will show evidence of TB and treponematosis in their skeletal remains. However, there are several important points that warrant further consideration.

When collapsing the possible and likely categories, it is seen that there are only 3 cases of TB and 7 cases of treponematosis. Indeed, these are not extraordinarily large numbers. However, many more people could have suffered from TB and treponematosis without ever revealing evidence of such affliction in their skeletal remains. It must be understood that osteological responses to these pathologies take a great deal of time to develop and do so in only the most chronic cases (El-Najjar 1979).

The chronic nature of infectious skeletal lesions introduces an inquiry regarding the health status of those who occupied the Orendorf site. This question is best addressed in the realm of a complicated dichotomy that has occupied a definite position in paleopathological research for the last decade. This dichotomy, known as the osteological paradox, deals directly with the notion of the length of time necessary for skeletal lesions to appear with some pathological conditions. Since this process is time consuming, it raises the issue of whether those who lived long enough to develop osteological responses to infectious conditions are really healthier than those without lesions in a population (Wood, et al. 1992:345). It really is not possible to settle this debate with the results of this study. However, this paradox, coupled with the low numbers of cases of TB and treponematosis in Orendorf, makes one wonder if several others suffered from these conditions but did not have the immune capabilities to become chronic cases.
Some scholars have proposed that prehistoric societies did not have the necessary population size to sustain a density-dependent disease like TB (Cockburn 1963; Morse 1969). However, others have stated that the presence of major population centers in North America could have supported infectious diseases (Buikstra 1999). In regards to Orendorf, those excavated at the cemetery only provide a representation of the total population of the site. Many more could have resided there and were either not interred in same locale as others or were simply not excavated. Therefore, it is probable that the total population of the Orendorf site at one time could have been that which Santure estimated, that is, 400-500 individuals (Santure 1981).

Maintenance of infectious disease across simulated prehistoric societies is the subject of a study undertaken by McGrath (1988). She believes that effective population size is the vital determinant for the survival of communicable pathogens, specifically TB, within a group of people without depleting the host population or pathogen completely. Her study concluded that the effective population size for TB is between 180 and 440 individuals (McGrath 1988). Therefore, when considering Santure’s population estimate of 400-500 at the Orendorf site (Santure 1981), it is reasonable to assume that TB could have been maintained within this society.

Since Orendorf is not a population that embraced thousands of people but still demonstrated evidence of TB, it is noteworthy to revisit the issue of which tuberculous Mycobacterium could be responsible for this disease process. Stead (2000) states that \( M. bovis \) is not likely to cause an epidemic of TB infection, as does \( M. tuberculosis \). The bovine strain is probably better suited to prehistoric societies, such as Mississippian populations, where it can become endemic and not cause mass casualties, as would be expected in an
epidemic situation. Ancient people in all likelihood contracted TB from eating infected meat from wild fauna, but not cattle (Stead 2000). Additional support is given to the assumption that *M. bovis* caused the tuberculous lesions in the Orendorf sample from the belief that this strain is "...ten times more likely to produce vertebral and other bone lesions than is *M. tuberculosis..." (Stead 2000:15).

In regards to treponematosis, it has been previously stated that it is not the purpose of this research project to determine which of the treponemal diseases is accountable for the skeletal manifestations of the cases of treponematosis. Even though some researchers have attempted such discrimination (Cook 1979; Powell 1991; Rothschild and Rothschild 1995; Schermer, et al. 1994), the ambiguous nature of treponemal lesions was beyond my expertise or the techniques used here. About the best that can be offered at this time is that the only condition that cannot be held responsible for the pathologic states displayed in the presented treponematosis cases is pinta, as this disease does not affect bone (Aufderheide and Rodriguez-Martin 1998).

Much of the early literature in regards to TB and treponematosis was filled with disputes regarding prehistoric manifestation of these diseases. The focus of this study has not been to resolve these debates, although they do deserve brief mention at this time. The controversy with TB evolved for two principle reasons. The first is that the skeletal pathology of TB is quite similar to that of other conditions (Buikstra 1976a; Morse 1969). As demonstrated in this study, it is sometimes very difficult to distinguish osteological manifestations of TB from those of other pathological conditions. Secondly, there were some problems with the dating of some prehistoric sites that had evidence of TB, such as the Nash site in Tennessee (Morse 1969). Collectively, the ambiguous skeletal pathology and
archaeological problems with dating provided much uncertainty when dealing with ancient
evidence of this disease in the New World (Morse 1969; Steinbock 1976). However, the
increasing amount of paleopathological evidence of TB in prehistoric populations (see
Buikstra 1999 for a summary), in tandem with new molecular studies on cases previously
purported to have tuberculous skeletal lesions (Braun, et al. 1998; Haas, et al. 2000; Salo, et
al. 1994) have helped to dispel the notion that TB was not present in the New World prior to
contact.

The controversial issue with treponematosis is centered more around its origins rather
than its presence in the New World prior to European contact. The bioarchaeological record
is filled with cases that support its existence in ancient New World populations (Baker and
Therefore, the question becomes one concerned with the incidence of treponematosis in the
Old World, i.e. was it present in this region of the world prior to explorative voyages to the
Americas (Baker and Armelagos 1988; Steinbock 1976)? Further, it is felt that
treponematosis was always present in the Old World but was miscategorized as ‘leprosy’
(Baker and Armelagos 1988). This notion is supported by numerous references to a
“venereal leprosy” in 13th and 14th century Europe (El-Najjar 1979; Steinbock 1976) in
addition to the similar skin changes exhibited by leprosy and treponematosis (Hudson 1965).
Again, it is not the point of this study to resolve this issue, but it is important to have a
historical perspective on paleopathological study of treponematosis. However, the results of
this study do further support the presence of prehistoric treponematosis in the New World.
Discussion of Statistical Analysis

Statistical analysis performed on the number of cases of TB and treponematosis in the Orendorf population with other prehistoric populations reveal some interesting findings. When comparing the cases of TB to Schild and Moundville, two Mississippian sites, it was found that there are not significant differences between these sites in regards to the number of cases. It should be remembered that there is one juvenile case included in the Schild results. Whether this influenced the statistical analysis is unknown at the present time. In addition, it is appropriate to mention here that at the Schild site, there are no cases of TB in either Middle Woodland (0/216) or Late Woodland (0/350) individuals (Buikstra and Cook 1981). When comparing the Orendorf TB cases to those at Norris Farms #36, an Oneota site, a different result is found. It is discovered that there is a significant statistical difference in regards to the number of TB cases between the sites, as Norris Farms #36 has a higher number of cases. What is particularly intriguing is that Oneota is the cultural tradition that immediately follows the Mississippian and therefore, may have contained cultural attributes that could have partially influenced the number of cases of infectious disease. One of these attributes is evidence of interpersonal violence (Milner and Smith 1990) that may have directly have contributed to increased biological stress, and hence, increased susceptibility to disease (Buikstra 1999). It would be interesting to compare these numbers across other Oneota populations to see if the same pattern emerged.

It is much more problematic to compare the number of treponematosis cases in the Orendorf population to other sites. This difficulty arises because of the presentation of the data in regards to other sites. In other words, these studies (Cook 1976; Lallo 1973; Powell 1985; Powell 1988) essentially present their findings according to the number of skeletal
elements affected (e.g. 10 tibiae demonstrate periosteal thickening on the anterior surface), rather than as individual diagnostic cases. This methodology presents a problem for any study that analyzes its data according to individual cases (such as the current investigation). Counting the number of affected bones really does not give an idea of how many persons suffered from any particular pathology, it just tells you how many skeletal elements had evidence of such pathology. Such reporting lacks the holistic interpretation that is missing from many paleopathological studies. If the goal of this field is to better understand the health of past populations, it seems much more logical to present the findings in a population perspective, rather than with such a narrow focus.

With that said, attention must be turned back toward the issue of comparing the number of treponematosis cases in the Orendorf populations to another site. The only site that had comparable data was Norris Farms #36. After completing the Chi-Square analysis, it is determined that there is not a significant difference between these groups in regards to the number of cases.

Even though prevalence rates were not subject to statistical analysis, they do provide a bit of a different comparative perspective. For TB, prevalence was 6.9% for the Schild site, 2.6% for Moundville, and 8.3% for Norris Farms #36. When comparing these figures to the prevalence rate of 2.6% for Orendorf, it is discovered that this percentage is exactly the same as that of Moundville. This is interesting, considering that the number of individuals in the Moundville investigation is almost four times that of Orendorf. In regards to the other sites, the percentages do not appear to be that dissimilar, although differences in sample size could be a contributing factor. For treponematosis, prevalence was 4% for Norris Farms #36. Again, this is not that different from the rate of 6% for Orendorf.
Taphonomic Damage, Porosity, and Osteoarthritis

The percentage of individuals that exhibited taphonomic damage to their vertebral elements is 18.8%. This damage ranged from tool marks to erosion that resembled lytic lesions of TB. Obviously, such damage made it more cumbersome to ascertain the presence of tuberculous lesions in these individuals. The morphology of some tool marks can look very much like a round lytic focus in a vertebrae. However, one must look carefully at the edges of such damage. If the edges are jagged and are not the same color as surrounding bone, then it is likely that one is dealing with excavation damage. On the other hand, taphonomic erosion poses much more of a challenge for the researcher. Sometimes this type of activity looks practically identical to the lytic nature of severe TB involvement, which can make it laborious to differentiate between the two.

Several individuals also displayed areas of microporosity on their vertebral centra (17.1%). This manifestation can also be confusing for the researcher, as this could be interpreted in a few ways. The first is that these regions of porotic activity could be the earliest representations of TB in the spine, as seen in cases that were presented in Baker (1999), as well as in Burial 105. The second is that this may simply be normal variation between individuals. Finally, this porosity could also be the result of undetermined taphonomic processes.

Finally, 35% of the sample was affected by vertebral osteoarthritis that included lipping and osteophyte formation around joint surfaces, as well as Schmorl’s nodes. While none of these cases was severe enough to demonstrate fusion of two or more adjacent vertebrae that could be mistaken for TB, some of the more moderately affected burials did
exhibit curled osteophyte formation with accompanying porosity. These characteristics are not indicative of TB, but like taphonomic damage and porosity, do introduce additional factors that had to be considered during macroscopic examination of the remains.

**Future Research**

In order to elicit a more comprehensive view of disease frequency in the Orendorf population, there are some considerations that could be taken account for future investigations. The first would be to include juveniles in the sample. This would not only garner a more comprehensive view of the entire population, but would also make it easier to compare the results to other studies that included juveniles in their samples.

Molecular examination is another type of study that could tell much about the presence of TB and treponematosis in the Orendorf population. These types of studies are perfect complements to those that utilized macroscopic and radiologic examination alone and can provide sound support to previous findings. Some researchers have utilized molecular DNA analysis in ancient skeletal remains purported to have lesions suggestive of TB (Braun, et al. 1998; Salo, et al. 1994). However, in regards to treponematosis, no research of this nature was able to be located.

Another direction that could be taken in future research efforts is disease modeling via the use of epidemiological principles. Examples of calculations that could be considered are attack rate (AR), relative risk (RR), and odds ratio (OR). Such methodology could provide yet another unique viewpoint that is not often embraced in paleopathological literature. Also, much more could be learned about how prehistoric communities adapted to various pathogens, much in the same way that modern epidemiological techniques do about
current populations. However, some authors have advocated that there are many obstacles in trying to apply modern epidemiological formulas to ancient disease. The fundamental premise that you can never excavate every individual that occupied a site prevents one from determining the total population size to use for calculations (Buikstra 1999).

**Conclusion**

To reiterate those statements presented in the introduction, this study did provide some insight into the health and welfare of the Orendorf people. While there are some implications to be considered in future endeavors of this kind, overall, much has been learned about some of the biological stresses placed upon those individuals that occupied this site. Further, there is the potential for upcoming examinations on epidemiological modeling.

This is the first in-depth investigation of infectious disease in the Orendorf population. From this, a different method of dealing with paleopathological data has been put forth. It is hoped that by tailoring these studies toward viewing cases on an individual basis, in contrast to counting affected elements, is a step in the right direction to better understanding infectious disease in ancient populations.
APPENDIX 1: INVENTORY OF BURIALS
<table>
<thead>
<tr>
<th>Burial #</th>
<th>Age</th>
<th>Sex</th>
<th>TD</th>
<th>P</th>
<th>OA</th>
<th>PTB</th>
<th>PTR</th>
<th>LTB</th>
<th>LTR</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40-50</td>
<td>M</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>40-50</td>
<td>F</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>25-30</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>15-20</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>20-25</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13a</td>
<td>20-35</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only cranium present</td>
</tr>
<tr>
<td>16</td>
<td>20-25</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>50+</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>remains incomplete and very fragmentary</td>
</tr>
<tr>
<td>21b</td>
<td>Adult</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>40-45</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>45-50+</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>20-35</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains incomplete and weathered</td>
</tr>
<tr>
<td>30</td>
<td>15-20</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>35a</td>
<td>20-35</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains incomplete and poorly preserved</td>
</tr>
<tr>
<td>36</td>
<td>35-50</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>40-45</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>40-50</td>
<td>?</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Adult</td>
<td>F?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>only lower legs and feet are present</td>
</tr>
<tr>
<td>47</td>
<td>35-50</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>only cranium and Cl present</td>
</tr>
<tr>
<td>50</td>
<td>20-35</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>remains incomplete, fragmentary</td>
</tr>
<tr>
<td>51</td>
<td>Adult</td>
<td>F?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>remains incomplete and fragmentary</td>
</tr>
<tr>
<td>55</td>
<td>20-30</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>56</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>58</td>
<td>20-30</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>60c</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>3 adult fragments associated with juvenile remains</td>
</tr>
<tr>
<td>62</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>remains fragmentary and incomplete</td>
</tr>
<tr>
<td>63b</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>only 5 bone fragments and 4 teeth present</td>
</tr>
<tr>
<td>65</td>
<td>Adult</td>
<td>F?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>remains incomplete and fragmentary; may be commingled with a juvenile fragment</td>
</tr>
<tr>
<td>66</td>
<td>50+</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td>no skull</td>
</tr>
<tr>
<td>66a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>adult fragments comingled with juvenile fragments</td>
</tr>
<tr>
<td>68</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>consists only of cranial remains embedded in dirt</td>
</tr>
<tr>
<td>Burial #</td>
<td>Age</td>
<td>Sex</td>
<td>TD</td>
<td>P</td>
<td>OA</td>
<td>PTB</td>
<td>PTR</td>
<td>LTB</td>
<td>LTR</td>
<td>Notes</td>
</tr>
<tr>
<td>--------</td>
<td>--------</td>
<td>-----</td>
<td>----</td>
<td>---</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>70d</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of foot and vertebral elements; commingled with juvenile remains</td>
</tr>
<tr>
<td>71</td>
<td>20-35</td>
<td>M</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>71d</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>fragmentary remains commingled with at least 3 other subadult individuals</td>
</tr>
<tr>
<td>72</td>
<td>50+</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of approximately 6 adult rib fragments</td>
</tr>
<tr>
<td>73b</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of approximately 6 teeth and 50+ bone fragments</td>
</tr>
<tr>
<td>74</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>75</td>
<td>40-50</td>
<td>M</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only upper half of body is present</td>
</tr>
<tr>
<td>76</td>
<td>15-20</td>
<td>F</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>35-45</td>
<td>M</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of several teeth and many other tiny bone fragments</td>
</tr>
<tr>
<td>82</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>83</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>84</td>
<td>40-50</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>30-40</td>
<td>F</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>bones of 2 juveniles included</td>
</tr>
<tr>
<td>87</td>
<td>40-45</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>88</td>
<td>20-25</td>
<td>F</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>88a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of a scapula and clavicle fragment</td>
</tr>
<tr>
<td>89</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>90a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of some cranial fragments</td>
</tr>
<tr>
<td>91a</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>94</td>
<td>Adult</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of cranial and a few post-cranial fragments; no aging criteria available</td>
</tr>
<tr>
<td>95</td>
<td>Adult-25+</td>
<td>?</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of miscellaneous cranial and post-cranial fragments; 25+ due to fusion of medial clavicle</td>
</tr>
<tr>
<td>98a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of a few post-cranial fragments</td>
</tr>
<tr>
<td>100 assoc bones</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>adult post-cranial fragments commingled with juvenile remains</td>
</tr>
<tr>
<td>104</td>
<td>Adult (?50+)</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of a few cranial and post-cranial fragments; obliteration of sutures on cranial fragments suggest old adult</td>
</tr>
<tr>
<td>105</td>
<td>15-20</td>
<td>M</td>
<td>?X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burial #</td>
<td>Age</td>
<td>Sex</td>
<td>TD</td>
<td>P</td>
<td>OA</td>
<td>PTB</td>
<td>PTR</td>
<td>LTB</td>
<td>LTR</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----</td>
<td>----</td>
<td>---</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>107</td>
<td>45-50</td>
<td>F</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>108</td>
<td>50+</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>109</td>
<td>25-30</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>110a</td>
<td>40+</td>
<td>F?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains in very poor condition; no pelvis</td>
</tr>
<tr>
<td>112</td>
<td>40-45</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>113</td>
<td>30-35</td>
<td>M</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>114</td>
<td>Adult ?</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of some adult lower limb remains</td>
</tr>
<tr>
<td>116</td>
<td>40-45</td>
<td>F</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>119</td>
<td>50+</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>20-25</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>121</td>
<td>35-45</td>
<td>M</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>123</td>
<td>40-50</td>
<td>F</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>could be older, only a few obliterated cranial sutures and auricular surface for aging</td>
</tr>
<tr>
<td>124, 125, 128</td>
<td>Skull #2:</td>
<td>45-50+ (?)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MNI=3; contains commingled cranial and postcranial elements that may represent 2 males and 1 female</td>
</tr>
<tr>
<td>126</td>
<td>35-50</td>
<td>M?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains incomplete and poorly preserved</td>
</tr>
<tr>
<td>127</td>
<td>35-45</td>
<td>F</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no skull available</td>
</tr>
<tr>
<td>127a</td>
<td>Adult</td>
<td>?</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of various vertebral, cranial, and postcranial fragments</td>
</tr>
<tr>
<td>129 &amp; 130</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>adult fragments commingled with juvenile remains; 129 is an adult (MNI=1) and 130 is a juvenile</td>
</tr>
<tr>
<td>133</td>
<td>40+?</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available; only have cranial and a few postcranial fragments</td>
</tr>
<tr>
<td>134</td>
<td>25-35</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>135</td>
<td>30-40</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>136</td>
<td>40-50</td>
<td>M</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only right and left tibiae, fibulae, patellae, and feet present</td>
</tr>
<tr>
<td>137</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of 1 hand phalange, 1 sacral, 2 rib, and 2 cortical fragments as well as 2 premolars</td>
</tr>
<tr>
<td>138b</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>139</td>
<td>40-50</td>
<td>F</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of 6 phalanges and a few other miscellaneous bone fragments</td>
</tr>
<tr>
<td>139b</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burial #</td>
<td>Age</td>
<td>Sex</td>
<td>TD</td>
<td>P</td>
<td>OA</td>
<td>PTB</td>
<td>PTR</td>
<td>LTB</td>
<td>LTR</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----</td>
<td>----</td>
<td>----</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>140</td>
<td>15-20</td>
<td>F</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>adult bone fragments commingled with infant fragments; MNI=1 adult</td>
</tr>
<tr>
<td>assoc with 140</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>143</td>
<td>35-50</td>
<td>F</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>144</td>
<td>20-25</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no pelvis available</td>
</tr>
<tr>
<td>146</td>
<td>35-50</td>
<td>M</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains very fragmentary and poorly preserved</td>
</tr>
<tr>
<td>147</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains extremely fragmentary and poorly preserved</td>
</tr>
<tr>
<td></td>
<td>40-50</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no skull available</td>
</tr>
<tr>
<td>assoc with 148</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>149</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of some arm, leg, and facial fragments</td>
</tr>
<tr>
<td>150a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of adult tibial fragments</td>
</tr>
<tr>
<td>teeth possibly assoc with 150</td>
<td>Middle adult (35-50)?</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of a few adult teeth; moderate tooth wear hints at &quot;middle adult&quot;</td>
<td></td>
</tr>
<tr>
<td>152</td>
<td>35-45</td>
<td>M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no skull available</td>
</tr>
<tr>
<td>153</td>
<td>40-45</td>
<td>M</td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td>consists only of a vertebral fragment, teeth, and cranial fragments</td>
</tr>
<tr>
<td>154</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>contains several miscellaneous bone fragments</td>
</tr>
<tr>
<td>155</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>155 &amp; 158 (&amp;160?)</td>
<td>Adult</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>commingled adult remains; MNI=2</td>
</tr>
<tr>
<td>156</td>
<td>20-35</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>remains are incomplete, highly fragmented, and poorly preserved; very little aging and sexing criteria available</td>
</tr>
<tr>
<td>157</td>
<td>35-50</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>see 156 above</td>
</tr>
<tr>
<td>158 (?) &amp; 160</td>
<td>Skull A: middle adult?</td>
<td>Skull A: male</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2 adult skulls commingled with other adult remains; MNI=4</td>
</tr>
<tr>
<td></td>
<td>Skull B: adult</td>
<td>Skull B: female</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burial #</td>
<td>Age</td>
<td>Sex</td>
<td>TD</td>
<td>P</td>
<td>OA</td>
<td>PTB</td>
<td>PTR</td>
<td>LTB</td>
<td>LTR</td>
<td>Notes</td>
</tr>
<tr>
<td>---------</td>
<td>-------</td>
<td>-----</td>
<td>----</td>
<td>---</td>
<td>----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----------------------------------------------------------------------</td>
</tr>
<tr>
<td>159</td>
<td>Adult</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Remains poorly preserved; no age indicators present</td>
</tr>
<tr>
<td>161</td>
<td>Adult</td>
<td>F?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only assorted cranial and postcranial fragments</td>
</tr>
<tr>
<td>162</td>
<td>Adult</td>
<td>M?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists only of pelvic, arm/hand fragments, and hundreds of tiny bone fragments</td>
</tr>
<tr>
<td>163</td>
<td>Adult</td>
<td>M?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists of various long bone, pelvic, hand, and rib fragments</td>
</tr>
<tr>
<td>163a</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>only available elements are 2 carpals and 4 metacarpals</td>
</tr>
<tr>
<td>163b</td>
<td>30-40</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“A”</td>
<td>35-45</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>“C”</td>
<td>Adult</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>consists of lower leg bones that were boxed with 146; MNI=1</td>
</tr>
<tr>
<td>“D”</td>
<td>25-35</td>
<td>F</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>no skull available</td>
</tr>
</tbody>
</table>

**Key:** TD-vertebral taphonomic damage; P-vertebral porosity; OA-vertebral osteoarthritis; PTB-possible TB; PTR-possible treponematosis; LTB-likely TB; LTR-likely treponematosis
REFERENCES CITED

Aufderheide, A.C., and C. Rodriguez-Martin

Baker, B.J.

Baker, B.J., and G.J. Armelagos

Beaglehole, R., R. Bonita, and R. Kjellstrom

Braun, M., D.C. Cook, and S. Pfeiffer


Buikstra, J.E.

Buikstra, J.E.

Buikstra, J.E.
Buikstra, J.E.

Buikstra, J.E., W. Autry, E. Breitburg, L. Eisenberg, and N. van der Merwe

Buikstra, J.E., and D.C. Cook

Buikstra, J.E., and D.C. Cook

Buikstra, J.E., and D. Ubelaker, eds.

Chulay, J.D.

Clark, G.A., M.A. Kelley, J.M. Grange, and M.C. Hill

Cockburn, A.

Cockburn, T.A.

Conrad, L.A.

Cook, D.C.

Cook, D.C.


El-Najjar, M.Y.

Esarey, D. and L.A. Conrad
1981  The Orendorf Site preliminary working papers. Archaeological Research Laboratory, Western Illinois University, Macomb.

Fowler, M.L.

Friedland, J.S.

Goldstein, L.G.

Good, T.W.
Goodman, A.H., J. Lallo, G.J. Armelagos, and J.C. Rose
1984    Health changes at Dickson Mounds, Illinois (A.D. 950-1300). In

Gordis, L.

Griffin, J. B.
191.

Grosset, J.H.
1993    Bacteriology of tuberculosis. In Tuberculosis: a comprehensive international
Dekker, Inc.

Haas, F., and S.S. Haas
1999    Origins and spread of mycobacterium tuberculosis in the Mediterranean basin.
In Tuberculosis: past and present. G. Palfi, D. Dutour, J. Deak, and I. Hutas, eds.
Hungary: TB Foundation, Golden Book, Ltd.

Dutour, G. Palfi, and A.G. Nérlích
2000    Molecular evidence for different stages of tuberculosis in ancient bone

Hackett, C.J.
1967    The human treponematoses. In Diseases in antiquity: a survey of diseases,

Harn, A.D.
1978    Mississippian settlement patterns in the central Illinois River valley. In
Press.

Harn, A.D.

Harn, A.D.
1991    The Eveland site: inroad to Spoon River Mississippian society. In New
perspectives on Cahokia: views from the periphery. J.B. Stoltman, ed. Pp. 129-153,
Hershkovitz, I., B.M. Rothschild, O. Dutour, and C. Greenwald

Hudson, E.H.

Kelley, M.A., and M.Y. El-Najjar

Kelley, M.A., and M.S. Micozzi

Kelly, J.E.

Kelly, J.E.

Kelly, J.E.

Lallo, J.W.
1973 The skeletal biology of three prehistoric American Indian societies from Dickson Mounds. Ph.D., University of Massachusetts.

Lallo, J.W., and J.C. Rose

Larsen, C.S.
Manchester, K.

McGrath, J.W.

Milner, G.R.

Milner, G.R.

Milner, G.R.

Milner, G.R., and V.G. Smith

Morse, D.

Morse, D.

Morse, D., and P. Morse

Muller, J.
Musher, D.M., and R.E. Baughn

Ortner, D.J.

Ortner, D.J., and W.G.J. Putschar

Ostroff, S.M., and J.W. Leduc

Powell, M.L.
1985  Health, disease, and social organization in the Mississippian community at Moundville. Ph.D., Northwestern University.

Powell, M.L.

Powell, M.L.

Price, S.A.

Roberts, C., and K. Manchester

Roberts, C.A.
Rothschild, B.M., and C.R. Rothschild

Salo, W.L., A.C. Aufderheide, J.E. Buikstra, and T.A. Holcomb

Santure, S.K.

Schermer, S.J., A.K. Fisher, and D.C. Hodges

Schwartz, J. H.

Smith, B.D.

Stead, W.W.


Steadman, D.W.

Steadman, D.W.
Steadman, D.W.

Steinbock, R.T.

Stirland, A.

Thoen, C.O.

Tramont, E.C.

Tuli, S.M.

White, T.D.

Wolinsky, E.


Young, B.W., and M.L. Fowler