Bioarchaeology of compassion: Exploring extreme cases of pathology in a Bronze Age skeletal population from Tell Abraq, U.A.E.

Jamie D. Vilos

University of Nevada, Las Vegas

Repository Citation


https://digitalscholarship.unlv.edu/thesesdissertations/967

Follow this and additional works at: https://digitalscholarship.unlv.edu/thesesdissertations

Part of the Biological and Physical Anthropology Commons, Disorders of Environmental Origin Commons, and the Pathological Conditions, Signs and Symptoms Commons

This Thesis is brought to you for free and open access by Digital Scholarship@UNLV. It has been accepted for inclusion in UNLV Theses, Dissertations, Professional Papers, and Capstones by an authorized administrator of Digital Scholarship@UNLV. For more information, please contact digitalscholarship@unlv.edu.
BIOARCHAEOLOGY OF COMPASSION: EXPLORING EXTREME CASES OF PATHOLOGY IN A BRONZE AGE SKELETAL POPULATION FROM TELL ABRAQ, UAE

by

Jamie D. Vilos

Bachelor of Arts
Illinois Wesleyan University
2002

A thesis submitted in partial fulfillment of the requirements for the

Master of Arts Degree in Anthropology
Department of Anthropology
College of Liberal Arts

Graduate College
University of Nevada, Las Vegas
May 2011
THE GRADUATE COLLEGE

We recommend the thesis prepared under our supervision by

Jamie D. Vilos

entitled

Bioarchaeology of Compassion: Exploring Extreme Cases of Pathology in a Bronze Age Skeletal Population from Tell Abraq, UAE

be accepted in partial fulfillment of the requirements for the degree of

Master of Arts in Anthropology

Debra L. Martin, Committee Chair
Jennifer Thompson, Committee Member
Allan Simmons, Committee Member
John Curry, Graduate Faculty Representative

Ronald Smith, Ph. D., Vice President for Research and Graduate Studies and Dean of the Graduate College

May 2011
ABSTRACT

Bioarchaeology of Compassion: Exploring Extreme Cases of Pathology in a Bronze Age Skeletal Population from Tell Abraq, UAE

by

Jamie D. Vilos

Dr. Debra Martin, Examination Committee Chair
Professor of Anthropology
University of Nevada, Las Vegas

Tell Abraq is a Bronze Age archaeological site located in the modern day United Arab Emirates and was occupied from the 3rd millennium BC to the 1st century AD. The coastal location provided access to both marine and agricultural resources as well as trade routes and foreign exchange. The tomb at the site was in use for 200 years (2200-2000 BC) and housed the commingled remains of a minimum of 286 adults. These individuals lived hard lives, dependent on good health to maintain a life-line of sustenance for themselves and each other. A number of individuals with severe expressions of pathological cases, however, indicate they were in need of support from others during their times of illness or injury. These pathologies include osteoarthritis with eburnation, stress fracture, healed mal-union fracture, spondylosis deformans, dislocated knee, and osteomyelitis. Using clinical literature, each case is interpreted based on current medical notions of disability and pain. Limited mobility and diminished capacity to provide for oneself lend to a biocultural analysis in which compassion is displayed through extended care and support to ailing and injured people. This research brings focus to an area of study that has received little attention,
attempts to highlight individuals in a commingled context, and suggests ways of integrating bioarchaeology in a community.
ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. Debra Martin, and my committee, Dr. Jennifer Thompson, Dr. Alan Simmons, and Dr. John Curry, for their help and guidance throughout the research process and writing of this thesis. I would also like to express my appreciation to the UNLV Department of Anthropology and the Graduate and Professional Student Association whose assistance has allowed me to share this research both on and off campus. Last but not least, I am extremely grateful to my family and friends who supported me on all levels during this endeavor.
# TABLE OF CONTENTS

ABSTRACT ........................................................................................................................................ iii

ACKNOWLEDGEMENTS ................................................................................................................... v

LIST OF FIGURES ............................................................................................................................. viii

CHAPTER 1 INTRODUCTION ........................................................................................................... 1
   Background on Tell Abraq .............................................................................................................. 2
   Paleopathology, Disabilities, and Compassion ............................................................................. 4

CHAPTER 2 MATERIALS AND METHODS ...................................................................................... 15
   Materials ......................................................................................................................................... 15
   Methods ......................................................................................................................................... 15

CHAPTER 3 CASE STUDY #1: ADULT WITH EXTREME OSTEOARTHRITIS AND EBURNATION (#9347) .................................................................................................................. 22
   Description ....................................................................................................................................... 22
   Differential Diagnosis ..................................................................................................................... 24
   Etiology ........................................................................................................................................... 25
   Implications for Disability and Care of the Individual at Tell Abraq ........................................... 27

CHAPTER 4 CASE STUDY #2: ADULT WITH A MAL-UNION FRACTURE (#1835/2557) ................................................................................................................................. 31
   Description ....................................................................................................................................... 31
   Differential Diagnosis ..................................................................................................................... 33
   Etiology ........................................................................................................................................... 34
   Implications for Disability and Care of the Individual at Tell Abraq ........................................... 39

CHAPTER 5 CASE STUDY #3: ADULT WITH A STRESS FRACTURE (#2680) ................................................................................................................................. 43
   Description ....................................................................................................................................... 43
   Differential Diagnosis ..................................................................................................................... 45
   Etiology ........................................................................................................................................... 46
   Implications for Disability and Care of the Individual at Tell Abraq ........................................... 48

CHAPTER 6 CASE STUDY #4: ADULT WITH A DISLOCATION WITH OSTEOARTHRITIS (#4526) .................................................................................................................. 50
   Description ....................................................................................................................................... 50
   Differential Diagnosis ..................................................................................................................... 52
   Etiology ........................................................................................................................................... 53
   Implications for Disability and Care of the Individual at Tell Abraq ........................................... 55
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Anterior view of patella (#9347)</td>
<td>23</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Posterior view of patella (#9347)</td>
<td>24</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Anterior view of radius (#1835 &amp; #2557)</td>
<td>32</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Anterior view of radius (#1835 &amp; #2557) enlarged at callus</td>
<td>32</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Anterior view of normal radius</td>
<td>33</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Superior view of talus (#2680)</td>
<td>44</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Inferior view of talus (#2680)</td>
<td>44</td>
</tr>
<tr>
<td>Figure 8</td>
<td>Anterior view of femur (#4526)</td>
<td>51</td>
</tr>
<tr>
<td>Figure 9</td>
<td>Medial view of femur (#4526)</td>
<td>51</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Inferior view of femur (#4526)</td>
<td>52</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Anterior view of tibia fragment (#11579)</td>
<td>59</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Anterior view of tibia fragment (#11579) enlarged at cloaca</td>
<td>59</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Anterior view of lumbar vertebra (#25550)</td>
<td>67</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Superior view of lumbar vertebra (#25550)</td>
<td>67</td>
</tr>
<tr>
<td>Figure 15</td>
<td>Inferior view of lumbar vertebra (#25550)</td>
<td>68</td>
</tr>
</tbody>
</table>
CHAPTER 1

INTRODUCTION

Expressions of disease and trauma on skeletonized human remains relay more than meets the eye. They can tell us the story of how people lived, cared, suffered, and survived. We must only imagine the graphic expressions of disease and trauma in a living person to help us illustrate this point. One need merely think of the consequences of a disease like polio or broken bone to be reminded of the intense pain and discomfort associated with it. Further complications, such as the condition of the soft tissues, bruising, swelling, tenderness, and decay also come to mind to strengthen this association. The difficulty that individuals experience with mobility, treatment of the symptoms, and remedy of the cause also have an impact on how people, as an individual and as a group, cope with these traumatic health events.

This research aims to contextualize these sorts of circumstances that affect the individual within a population. Starting with desiccated bone and putting on the layers of human flesh, this thesis builds a person and the community surrounding him or her. By looking at specific severe expressions of pathologies on bones, this project determines what malady was affecting an individual. Using clinical accounts and medical literature, ideas of the possible limitations, struggles, and quality of life this individual endured under this ailment as it healed are discussed. This research also considers the sources of support and care this individual received as a means to return him or her to a healthier condition.
These considerations comprise a novel way of examining healed expressions of severe pathologies.

For this study, a close examination is made of individuals who display extreme cases of pathology in order to understand how they were able to survive with those diseases or trauma and what their survival tells us about the community in which they lived. This project will focus on individuals from the Bronze Age site of Tell Abraq, UAE (to be discussed further below). The Tell Abraq individuals discussed here endured severe illness or trauma with the likely assistance of other members of this Bronze Age culture and so provide an ideal sample in which to assess levels of care and compassion.

Background on Tell Abraq

This project analyzes isolated and extreme cases of unusual diseases and trauma from individuals who lived in the Bronze Age archaeological site of Tell Abraq. Tell Abraq is located in the present-day United Arab Emirates, several kilometers inland from the coast of the Persian Gulf. Professor Daniel Potts of the University of Sydney and his team excavated the site over five field seasons between 1989 and 1998, and he found that it was one of the largest among other contemporary sites along the coast (1989, 1993, 2000a). The site was occupied from the Early Bronze Age (circa 2500 B.C.) to the Iron Age (circa 400 B.C.) (Potts 2000b). Faunal and floral evidence of fish, shellfish, camel, goat, dates, barley, and wheat indicate the community enjoyed a diverse diet supported by both marine and agricultural resources (Gutierrez 1994). Exotic artifacts such as
linen, hair combs, and ivory items suggest the site also played a significant role in a trade network involving areas such as Dilmun, Harappa, and Mesopotamia (Potts 2000a).

The main structure at the center of the site is a mud-brick fortification tower that was constructed in several phases over its millennia of occupation. Outside the fortified tower lies a circular tomb 6 meters in diameter. The style of the tomb is typical of others from the Umm an-Nar period (Arabian Bronze Age) with its two chambers separated by a dividing wall. A sealable passageway on its south side allowed access from the outside as well as to both chambers. Radiocarbon dating reveals the tomb was used for about 200 years (2200-2000 B.C.). This tomb is unique in that it is the only contemporary burial site that was not looted and was otherwise relatively undisturbed. The tomb was excavated over four field seasons by Professors Debra Martin and Alan Goodman from Hampshire College, Massachusetts. Four hundred thirteen individuals were placed in the tomb, and it is likely these were secondary burials. There is nothing to suggest preferential mortuary treatment for these individuals in the tomb. Over time in the small space of the tomb, a commingled burial formed as new individuals were interred atop the old, creating a bed of bone, soil, and artifacts 1.4 meters thick which complicated the excavation (Potts 2000a). The commingled nature of the remains creates a unique challenge for analysis in that studying complete individuals is impossible, with the exception of a few bodies that were preserved intact.
This challenge is not unlike that of other mass burials; however, another goal in studying a handful of severe cases is that it allows us to associate bones from the same individual from among intermingled parts. Complete skeletons from commingled disarticulated bones cannot normally be matched with any degree of accuracy to one individual, but certain articulating joints may be related if they exhibit the same pathological signature. For example, a dislocated hip joint will develop pathological signs at the acetabulum of the pelvis as well as on the head of the femur. If these bones were found to match in size and pathologies, it would be safe to assume these bones belong to the same individual. So while we cannot say as much about individuals in a commingled group as we could with intact burials, we can still identify a case of a dislocated hip from the entire group and attempt to illustrate who suffered this condition. In this way, studying isolated cases from the Tell Abraq tomb may shed additional light on a few of the individuals who were buried in the tomb and give us insight into the cultural ethics, morals, and beliefs in this Bronze age population.

Paleopathology, Disabilities, and Compassion

The field of paleopathology, or the study of diseases preserved in the bodies of ancient people, is a relatively young subdiscipline within biological anthropology, and there are many challenges to diagnosing specific disease on ancient human remains (Goldstein 1963, Ortner 2003, Aufderheide and Rodriguez-Martin 1998). Brothwell was a major player in the establishment of the field of paleopathology with his work on Neolithic remains in Britain. He was
among the first to publish on diagnoses and analyses of remains, both skeletal and dental (Goldstein 1963). His method for description and examination constitute a large part of the standards used today.

Interpretation of healed and healing lesions needs to consider what is referred to in anthropology as the osteological paradox (Wood et al. 1992). The paradox states that skeletons may reveal no signs of disease, but that does not mean that the people were healthy. Conversely, skeletons may display indicators of disease, but that does not mean they were unhealthy. Individuals who survived an injury or disease were sufficiently robust and healthy for bone healing to have taken place without causing death, especially in the time prior to the discovery of antibiotics. If the person survived, it suggests a healthier constitution than that of other people who succumb to the same illness and trauma. These latter individuals may reveal no injury or signs of disease on their skeletons because they died too quickly for bone to react. Despite the abnormal and unhealthy-looking bones that are presented in this research, these individuals were survivors; however, in many cases it is likely that they required aid from the people around them.

Studying pathological signatures on bone provides information on many aspects of daily life. Pathologies follow patterns of biology, environment, and behavior, which means there is much that can be inferred from the expression of a particular pathology. Paleoepidemiology, or the study of how certain diseases were distributed in ancient times (Stedman 2006), has provided the standard method of assessing disease through population-level analyses and frequencies.
This has its limitations, especially if sample sizes are not large and if there are problems of representation. Since we are focusing on individuals, this study offers additional information that can complement the population-level approach and provide a more nuanced view of the people being studied.

Extreme expressions of disease and trauma are, in and of themselves, interesting and unique with regard to populations as a whole. Numerous examples of pathologies are described and illustrated in catalogues of diseases (e.g. Aufderheide and Rodriguez-Martin 1998, Ortner 2003). These examples display what is often considered the abnormal condition for an ordinary person living, working, and surviving in fairly harsh and marginal environments such as those humans experienced thousands of years ago. Although severe pathologies may be relatively rare when compared with mild to moderate expressions of disease, they are important to study because they highlight the extremes to which some individuals were pushed. If these individuals survived the disease, they highlight how care and compassion within the community may have played a role in their recovery. This opens up a myriad of questions about the lives of those afflicted with these relatively severe and disabling diseases. How was their mobility affected by pathologies? Their daily habits? Their social status? Their self-sustainability and/or dependence on others in the community? Were all diseases and injuries treated the same way, both medically and socially? Addressing such questions may provide greater insight and a more nuanced view of care and compassion in the Tell Abraq community.
Mention of a disabled individual is met by preconceptions from modern-day attitudes towards those with disabilities. For the purposes of this study, the term “disability” refers to any pathological condition that limits one’s capacity to provide for oneself. Likewise, any sort of assistance to one with a disability, who would not have been likely to survive without such aid, falls under the realm of “care”, “empathy”, and “compassion”. While we cannot directly infer behaviors that express compassion from skeletal anomalies, analysis of isolated cases that present the degree of impact of the pathologies can help us frame the support system of the community (Dettwyler 1991, Hawkey 1998, Keenleyside 2003, Tilley and Oxenham n.d.).

**Compassion in an Evolutionary Context**

While thoughts cannot be inferred from skeletal remains, an attempt to understand why we would help others, especially those who are sick or injured, with or without some sort of benefit to motivate that decision is to understand what makes us human. This sort of behavior, as we know, is not limited to humans, and so by looking at our evolutionary counterparts and ancestors, we can gain insight into when and why we do this. The sociobiological concepts of behaviors to promote group or individual survival would help to further contextualize the patterns of healed pathologies.

In his book, The Age of Empathy: Nature’s Lesson for a Kinder Society, primatologist Frans de Waal (2009) discusses the topic of the capacity for compassion in both animals and humans. Many researchers, including de Waal, have focused on studies of violence and its roots in human evolution by citing
chimpanzee behaviors such as raiding, homicide, and infanticide. De Waal instead notes the behavior of Bonobo chimpanzees, which consists of mating behaviors to diffuse anger and other emotionally intense situations. It is only recently that scholars have begun to focus on the compassionate side, or at least expand this thinking beyond gender lines in humans.

Among other experiments mentioned in his book, de Waal explains one in particular which tested whether capuchin monkeys were interested in the welfare of others. A pair of the capuchin monkeys were separated but within sight of each other and the experimenters. The experimenters would barter with one of the monkeys, and in return, that monkey would be able to choose one of two tokens. One token was the “selfish” choice, awarding the bartering monkey a treat; the other token was the “prosocial” choice, awarding treats to both monkeys equally. After learning the meaning of the tokens, the bartering monkey would consistently choose the prosocial token. This choice, however, depended significantly on the strength of the relationship between the two monkeys. Whether or not this lends evidence to capuchin monkeys having concern for the welfare of others, the monkeys do seem to prefer sharing a treat than consuming one alone. Questions about their motivations, however, remain. Are the monkeys choosing the prosocial option because they know or expect reciprocation in the future? Are higher socially ranked monkeys more likely to be prosocial to groom their status? Desires for sharing and helping are difficult to distinguish from ultimately more selfish motives, but the behavior is nonetheless apparent in non-human primates.
In terms of human examples of caring for others, another recent study focuses on care for a human child from the Middle Pleistocene. Through differential diagnosis, Gracia and colleagues (2009) determined a human cranium belonging to a 5 to 12.5 year old child displayed signs of an uncommon birth defect, specifically craniosynostosis. The brain deformity associated with the defect would have affected motor and cognitive skills to the degree that the researchers claim may have required extra care for the child to have survived to its age at death. If nothing else, the early humans of this group did not seem to harm or mistreat the child, who instead received indiscriminate care despite its impairment (Gracia 2009). This study, along with Oxenham and Tilley’s (2009, n.d.) work, there has been little recent research that reflects the side of care and compassion for others among humans in prehistory.

There is yet another case of extended long-term care at Tell Abraq. Martin and Potts (Potts 2000a) have previously discussed an individual known as “Leslie”, the only complete and individual burial in the tomb. Leslie was found to have been a female aged 18-20 afflicted with a severe neurological disorder, possibly the earliest case of polio in the world (Potts 2000a). Skeletal analysis of her remains reveals she was at least partially paralyzed, meaning she would have required constant care, someone to feed, bathe, and mobilize this woman for a majority of her life. Her burial is unique in that her skeleton was bagged and remained separate from the commingled mass (Martin, personal communication). Grave goods associated with her burial were no more or less than others in the tomb. Questions remain as to whether Leslie may have
belonged to a higher socio-economic status or received differential treatment due to her condition. What is clear, however, is she was cared for despite her serious disability before and, with regard to her special mortuary treatment, after death. Her documented instance of care is also a prime motivation for why Tell Abraq is an interesting population in which to discover other pathological cases that required care.

**Bioarchaeology of Care**

Isolated cases can be very revealing for individuals who fall outside of the normal disease parameters of a given population in that they demonstrate the compassion and support of people on whom they depended for care. A recent study by Oxenham and colleagues (2009, n.d.) examines this in depth. In the case of one individual from Neolithic Vietnam classified as M-9, the researchers determined through differential diagnosis that he was disabled in childhood with Klippel-Feil Syndrome, a congenital fusion of the spine. M-9 died between the ages of 20 and 30 and would have been incapacitated, at minimum paralyzed in his lower body, for 10 years prior to his death. Given his disabilities, M-9 would not have likely been able to provide for himself without the aid of others in his community. This also begs the question of who his caretakers were—were they women or men? Kin or non-relations? This line of thought also raises questions about how poor health and disability were perceived, what resources were allocated for care, and what cultural knowledge was applied to assist disabled individuals. These queries may lie outside of what we can possibly deduce from
bioarchaeology, but they are nonetheless useful to ask. They also frame an approach Oxenham and Tilley call “the bioarchaeology of care” (n.d.).

Oxenham and Tilley’s approach is designed to be applied at the case-study level. They first incorporate archaeological evidence as a background to the physical and social environment of M-9. Demographic profiles, mortuary analyses, dietary resources, and physical landscape are considered based on available evidence. They also use modern clinical literature to assess physical ability and psychosocial health with the individual’s need for care. Care for an individual is considered whether assistance was required as a means for survival due to a chronic disability or during a healing or recovery period. Examples of care may have consisted of food provisions, water, shelter, transportation, dressing, personal hygiene, safety, general health maintenance, and nursing or other medical interventions (Tilley and Oxenham n.d.).

A number of studies have acknowledged the receipt of care but have done little to elaborate on the concept of prehistoric provision within a group or community. For example, Keenleyside (2003) examines an Alaskan Eskimo male with a dislocated mandible. She argues that this individual, along with most Eskimos with disabilities in historical accounts, were able to function with little to no assistance from other members of their community. Those who received assistance were given food and clothing, but sometimes disabled individuals were killed or abandoned under severe circumstances, as the challenging ecology of the Arctic likely limited resources, making non-working members a burden too great to carry. Historical accounts report disabled individuals who
were nonetheless active and productive members of the group, such as an individual with permanently contracted legs who, despite this, was still able to paddle a canoe and move around by crawling. The duration of the assistance does not matter; the fact that assistance is provided is evidence of compassion. The community was able to support this individual for the initial period of adjustment, during which time was needed to relieve pain and discomfort and to become familiar with new joint mechanics as the injury or disease healed. Cases involving prolonged care and healing are highly dependent on the physical limitations imposed by the condition, such as spinal injuries or defects.

Another example of a disabled individual receiving assistance is illustrated by Hawkey (1998), who describes a prehistoric individual from New Mexico who suffered juvenile chronic arthritis and was wholly dependent on other community members from childhood to middle adulthood. Premature epiphyseal fusion, muscle atrophy, and ankylosis of the joints are all features of this man’s skeletonized remains. While he was probably able to bring his hand to his mouth and feed himself, someone would have needed to bring him food. This dietary assistance, in addition to other aid, are the acts of compassion that allowed for this man to survive into adulthood.

Dettwyler (1991) challenges assumptions of disability and compassion in her review of several case studies. She makes the following arguments: the majority of community members are not necessarily productive and self-sufficient, not all disabilities are marked on the skeleton, an individual who is physically impaired can be productive, survival is not indicative of compassion,
and providing for an individual is not necessarily the compassionate thing to do. Her ethnographic accounts bolstering the statement that the archaeological record is unable to tell us whether individuals with disabilities were treated with compassion, tolerance, or cruelty is an especially valid, albeit subjective, line of reasoning. For the purposes of this research, however, an individual’s survival is considered evidence of care and compassion. Moreover, an individual’s treatment in life is often reflected in treatment after death (Tilley and Oxenham n.d.). Based on the evidence in the tomb at Tell Abraq, the placement of individuals and allocation of grave goods reveals no immediate distinction in health or status among those interred.

Although extreme expressions of pathologies documented in the people interred in the Tell Abraq tomb raise many interesting questions, my research questions specifically include the following:

- How many individuals within the tomb were suffering from extreme and relatively rare pathological conditions?
- What was the etiology and symptoms of these diseases and trauma?
- What does the presence of individuals with extreme cases of disease and trauma tell us about the culture, specifically in terms of care-taking and compassion?

In the next chapter, the materials and methods of this research will be described, along with a background on the methods. The following chapters delve into six case studies of individuals afflicted with an extreme paleopathology. The first individual was afflicted with severe osteoarthritis of the
kneecap, so much that the back of the bone has been worn away and polished. The second case study describes an individual with a broken bone in the forearm that healed incorrectly. The third case study details how an ankle stress fracture affected another individual. A knee joint dislocation with advanced arthritis on the femur is concerned in the case study of the fourth individual. The fifth individual developed a case of osteomyelitis in the tibia. The sixth case study portrays an individual with a fusing lumbar vertebra. Each of these cases was selected to highlight the diversity of pathologies found at Tell Abraq as well as to provide the interesting scenarios in which each individual lived with the ailment and the care that was required to aid in each adult's recovery. Based on this evidence, our observations show that the people of Tell Abraq exhibited care and compassion for their sick and injured. The final section of the thesis frames the research questions and further expands this new area of bioarchaeology that seeks to incorporate a wide range of anthropological and biomedical information in ways that illuminate how we can envision life for disabled and unhealthy people in prehistoric contexts.
CHAPTER 2
MATERIALS AND METHODS

Materials

The tomb at Tell Abraq consisted of at least 413 commingled skeletons, of which 286 were adults (based on the right talus) and 127 were subadults (based on the right femur). The collection is currently housed in UNLV’s Department of Anthropology human remains repository. The remains are disarticulated, and most are fairly well preserved, although crania, long bones, and pelves are fragmented. The method used in this study consists of examining only the adult skeletal material from the Tell Abraq collection, and subsequently identifying severe cases of extreme morphological deformities and traumatic modifications of bone. Preliminary assessments during this research have revealed a number of cases of pathologies including poliomyelitis, osteomyelitis, osteochondritis dessicans, osteoarthritic eburnation, and unset fractures. Severe cases were determined using Ortner’s (2003) and Aufderheide’s (1998) catalogue of pathological conditions. Observations of pathological conditions were deemed extreme if the case represented a clear example of an abnormality in the bone or most modified case among other less severe cases.

Methods

In order to correctly diagnose severe expressions of a disease one can make a case for using the method of differential diagnosis. Because various diseases can cause similar patterning of bone remodeling in their early stages,
ascertaining the cause of such slight remodeling may prove to be very difficult or otherwise leave open a wide range of causative agents. By examining pathological modification of bone in its extreme forms, we may be better able to determine identification of pathologies present than in their less severe forms. For example, a cancerous bone and a bone affected by tuberculosis may look very similar in early stages (such as periosteal reaction) but very different in later stages (Kelley and Mahmoud 1980, Ortner 2003, Aufderheide and Rodriguez-Martin 1998). Thus by examining extreme pathologies there is a greater chance of a positive disease diagnosis.

Differential diagnosis is a method frequently used in the medical field, and recently popularized by the diagnosticians on the television show “House M.D.” In the simplest terms, differential diagnosis is a systematic, problem-based process of elimination that physicians use to come to an ultimate diagnosis of a disease. From a broad range of possible diagnoses based on symptoms, age, sex, lifestyle, and biology, one can formulate a more focused and likely deduction of the disease entity causing the problem (Stedman 2006, Jamison 1999).

Using differential diagnosis actually broadens the range of possible causes of disease rather than restricting them. The broadened range of more inclusive categories of infection is more useful than attempting to narrow down a specific diagnosis. For example, if one was able to identify pathologies congruent with a neuromuscular disease, a diagnosis of “neuromuscular disease” is more beneficial and less limiting than attempting to further classify the pathology as Parkinson’s disease, multiple sclerosis, or a stroke. By considering a broader
type of disease to be included in a diagnosis, the chance of a positive diagnosis often increases as opposed to simply selecting one specific disease that may fit the description (Jamison 1999).

Differential Diagnosis in Bioarchaeology

Differential diagnosis is a method that has been employed in anthropology for many years. Digangi and colleagues (2009) worked on Mississippian site in east Tennessee and uncovered a mostly complete burial of an adult female aged 29-51 years (with an average of 39 years). The distinguishing characteristics of this individual are her abnormal limbs. The long bones of this woman are remarkably asymmetrical, the differences being 82 mm and 58 mm between the right and left humeri and femora, respectively. The authors catalog the possible conditions for this shortening as follows: chondrodysplasia punctata, enchondromatosis, or focal dermal hypoplasia, or 2 other bone tumor diseases. By developing this list of diseases that cause asymmetrical limb growth, considering the suite of traits affecting the bones, and describing how each disease would manifest in osseous material, Digangi and colleagues were able to find that a diagnosis of the condition enchondromatosis was most consistent with the pathologies exhibited by this woman.

Differential diagnosis was used both macroscopically and microscopically in Grupe’s (1988) study. A semi-complete adult (40-50 years) male burial from a northern German medieval cemetery was found with large osteolytic lesions. The lesions were thought to have occurred as a result of myeloma or carcinoma. By recording the anatomical pattern of reaction (vertebral column, proximal femora,
ribs, sternum, pelvis, etc) as well as the appearance of the lesions, Grupe determined that multiple myelomas could not explain the lesions and that instead metastasized carcinoma better fit the case.

Similarly to Grupe, Temple (2006) studied the lesions in individuals from the Los Muertos site. Coccidioidomycosis was known to have been endemic to the region, but Temple was careful to employ differential diagnosis before making any assumptions. He describes lesions and their location in detail, and uses microscopic and x-ray techniques to gain better views of the damage to the bone. He rules out carcinoma and tuberculosis in favor of mycotic infection based on the appearance and distribution of the lesions.

Challenges to Differential Diagnosis

The studies above provide good examples of how differential diagnosis is a very useful method, but it is not without its limitations. Most of the challenges we face in using this method are basically the same as with any pathological diagnoses. As with all skeletal material, we are at a disadvantage a priori without the ability to use soft tissue as a diagnostic trait. Another set of factors in studying paleopathology are sub-clinical manifestations. Since bone takes time to react to specific diseases, the agent could very well kill the sick individual before the reaction takes place. The specific challenge with this study, as mentioned earlier, is the disarticulated nature of the remains. A useful trait in differential diagnosis is the anatomical patterning of pathologies.

The process of using differential diagnosis with bioarchaeological material is the best known method for providing the diagnosis that best fits the limited
information at hand. Ortner (2003) emphasizes careful description of the pathology, noting its appearance, location, and type of pathology before making any attempt at diagnosis. Pathological changes to the bone, described in thorough and exhaustive detail, allow for others to assess the pathology when the report is published, sometimes without a visual aid. The utility of thorough description permits future researchers to re-evaluate how human remains are diagnosed as new information is obtained.

Additionally, using our modern classification of diseases can be problematic. Ortner warns that, historically speaking, our understanding of pathogens has changed, and what was once considered an erosive disease is now found to have infectious origins. Differential diagnosis, in addition to careful description, may help to avoid the pitfalls of making a false diagnosis that is too specific in character. Broader afflictions, such as tumors and infections, cannot necessarily be reduced to a single type of disease. This thesis attempts to overcome some of these challenges by employing the protocol outlined below.

**Protocol for Data Collection from the Tell Abraq Remains**

a) Differential Diagnosis: In order to provide an accurate diagnosis for the isolated and more extreme cases of disease on individuals buried in the tomb at Tell Abraq, differential diagnosis is applied using available published standards. These texts are also the standards by which the differential diagnosis was conducted. The research describes the pathological expression in detail and notes possible etiologies.
First, as stated previously, pathologies may never have a chance to alter bone. An otherwise healthy person afflicted with a disease may very well die before bone can react to the bodily stresses caused by the disease. Ortner (2003) estimates that of all possible diseases from which humans suffer, only a very small percentage of those diseases actually affect bone. Second, if the individual does survive a disease, bone can only react in a limited way; bone is either broken down through resorption, remodeled by ossification, or produced in a poor quality (Ortner 2003). The combination of these challenges makes any diagnosis difficult, which is why the severity of the reaction is a prime factor in selecting bone for analysis.

b) Age, Sex, and Other Factors: A number of other causes can also affect expression of a disease. Ortner (2003) lists factors such as sex of individual, age of individual, age of onset, nutritional status, immune response, social conditions, environmental conditions, and efficacy of treatment. Not all of these variables can be taken into account when studying an archaeological collection, but they are nonetheless important when evaluating the contextual evidence. Particular to Tell Abraq, the climate of the Arabian peninsula, the migration of people (especially traders), and the ecology of the vegetation and animals they consumed could all play a part in the transmission and proliferation of disease in the community. These factors also allow us to reconstruct subsistence practices and determine who would be at risk for the conditions we observe in the case studies. Just as well, we can note the types of activities that would have been difficult for an individual to perform while temporarily or permanently disabled.
c) Evaluation of Level of Care, Support and “Compassion”: The bioarchaeology of care is a relatively new concept and a fundamental consideration in this project. This idea draws on the development of empathy into compassion through the course of human evolution. Neanderthals (Trinkaus 1983), chimpanzees (McGrew 2007, O'Connell 1995) and other hominins (Hublin 2009, Silk 1992) are all thought to have displayed empathetic behavior or forms of altruism to varying degrees. A deeper background of these evolutionary roots is explored in the thesis; however, this research reinforces the link between modern day compassion and ancestral empathy and attempts to illuminate cross-cultural variation in the archaeological record. The final portion of the analysis places each individual with extreme pathology back into context of the community. Using available archaeological reconstructions of Bronze Age lifestyles, the amount of care and help that a person would have needed to cope with the symptoms and side-effects of the disease is inferred. This analysis is aided by the clinical and nursing literature on how much care individuals are provided today who have that disease. Historical and archival literature from the Near East may also help reconstruct what kinds of health care might have been available four thousand years ago.
CHAPTER 3

CASE STUDY #1: ADULT WITH EXTREME OSTEOARTHRITIS AND EBURNATION (#9347)

This chapter describes an individual in the Tell Abraq tomb with the disease commonly known as arthritis, or more simply, joint inflammation. The pathology is encompassed in both the clinical and anthropological literature by other similar names such as degenerative joint disease, osteoarthritis, rheumatic disease, connective tissue disease, and musculoskeletal disorder (Grelsamer and Loebl 1996, Jurmain 1999). The disease is clinically characterized in a living individual by swelling, stiffness, or pain in the joint or radiologically by joint space narrowing due to thinning of cartilage (Waldron 2009). Because these characterizations do not preserve in a skeletal sample, paleopathologists must use different criteria. The primary focus is change on the bone’s joint surface. This change may include pitting on the joint surface, new or reformed bone on the joint surface, extra bone growth on the margins of the joint (called osteophytes), or a shiny, polished joint surface due to bone against bone activity (called eburnation) (Jurmain 1999, Waldron 2009).

Description

While osteoarthritis and eburnation are prevalent on many of the remains from Tell Abraq, the most severe case appears on the posterior (back) side of a left patella (kneecap) (#9347). In this case, the bone element itself measures 4.42 cm maximum medial-lateral (left to right) breadth and 4.36 cm maximum
superior-inferior (top to bottom) height. The bone cortex of the anterior (front) surface is completely missing (see Figure 1). Osteophyte development occurs on the superior (upper), medial (inside), and lateral (outside) edges of the bone (see Figure 2). The inferior (bottom) edge as well as part of the lateral edge are too distorted by the missing bone to assess possible osteophytes.

Figure 1. Anterior view of patella (#9347)

The polished eburnated area (indicated by the arrow in Figure 2) covers 2.91 cm in maximum breadth and 2.45 cm in maximum height over the superior two-thirds of the entire posterior surface. Parallel grooves on the polished surfaced are clearly marked superior-inferiorly, which coincides with the motion of the patella against the distal articular surface of the femur (thigh bone). The
depression created by the eburnation is larger and deeper on the left side than the right (note the shadow in the darker area of Figure 2), which also lends to the nature of the siding of the bone (Bass 1995). Within the eburnated area as well as its margin, pitting also occurs, as demonstrated by the black and dark spots in Figure 2.

Figure 2. Posterior view of patella (#9347)

Differential Diagnosis

Although different changes to the joint surface of a bone occur at different stages of the disease, eburnation indicates an extreme stage of osteoarthritis. In fact, it is the undisputed diagnostic feature for osteoarthritis. The presence of other changes in bone like pitting and osteophyte development are considered
minor criteria that are only considered diagnostic when they can be coupled with one or more other minor features (Jurmain 1999, Waldron 2009). Without a doubt, this Tell Abraq adult suffered severe osteoarthritis.

Eburnation occurs after loss of the joint cartilage, and the underlying subchondral bone undergoes a reaction where the articular surface hardens. Over time, the successive mechanical wear of bone upon bone contact creates a smooth, polished surface (Jurmain 1999, Ortner 2003). Because the appearance of eburnation is largely unmistakable (Rogers and Waldron 1995, Ortner 2003, Aufderheide and Rodriguez-Martin 1998, Waldron 2009), the application of differential diagnosis is easily used here. It also comes as no surprise to find this case as well as other cases of eburnation on articular surfaces of bones that comprise joints.

**Etiology**

The knee is part of a synovial joint. The femur, tibia (shin bone), and patella are enclosed in a joint capsule lined with a membrane. The membrane normally secretes synovial fluid to lubricate the joint and, along with water from the articular cartilage on the bone surface, produces very little friction (Grelsamer and Loebl 1996, Mankin and Radin 1985).

Rather than describing the disease as a destruction of the joint surfaces, it is helpful to view osteoarthritis as more likely the process of normal bone repair and remodeling (Rogers and Waldron 1995, Sokoloff 1976). Tissue damage is still a result of osteoarthritis coupled with an immune reaction. The constant
stress on the joint can be seen affecting either the cartilage or the bone or both in stages. Cartilage is first challenged by load-bearing activities that cause it to swell but can still be repaired. Next, the cartilage begins to lose its elasticity and softens, narrowing the joint. Towards the end of this stage, lesions in the cartilage may expose the subchondral bone. Lastly, a sclerosis of the subchondral bone and trabeculae prepare the articular surface to take on the impact and weight-bearing activities without the cartilage buffer. Subsequently, eburnation, bone cysts, and hypertropic growth of osteophytes occur as an attempt to increase the load-bearing area (Grelsamer and Loebl 1996, Jurmain 1999, Swearingen 2007, Ortner 2003).

Osteoarthritis is often associated with degenerative or “wear and tear” from habitual movement and loading of the joints and thus is considered a disease of older individuals. Many factors, however, play a part in the individual’s chance of being afflicted by osteoarthritis. There are two forms of osteoarthritis: primary and secondary. Primary osteoarthritis is the more common type, and it develops mainly by aging, but sex, hormones, genetic predisposition and mechanical use also share in this dynamic (Waldron 2009, Weiss and Jurmain 2007, Zimmerman and Kelley 1982). Secondary osteoarthritis is initiated by traumatic incidents at the site of a joint which then affects bone growth.

Through the course of history and certainly at Tell Abraq, osteoarthritis has been one of the most prevalent diseases, and there are some general trends. In both modern and ancient populations, the knee joint is the area most commonly affected by degenerative joint disease, along with the hip, ankle and
foot, shoulder, elbow and wrist, and hand (Bridges 1992, Molnar et al. 2009, Zivanovic 1982). In modern populations, osteoarthritis is uncommon in individuals under the age of 40 (Waldron 2009). Women are also most commonly affected, but only over age 55 (Molnar et al. 2009). In archaeological groups, the prevalence of osteoarthritis is greater in males than in females but is not statistically significant (Bridges 1992, Jurmain 1999, Rogers and Waldron 1995). People of a higher socioeconomic status also display less arthritis (Bridges 1992, CDC 2008). Obesity is a more modern phenomenon that greatly affects rates of osteoarthritis, but this recent epidemic would not have affected archaeological populations (Grelsamer and Loebl 1996, Jurmain 1999). Given the variability of factors that contribute to osteoarthritis, it is difficult to determine age or sex of this Tell Abraq individual other than an adult.

Implications for Disability and Care of the Individual at Tell Abraq

Clinical symptoms of osteoarthritis include pain at the joint, swelling, stiffness, and tenderness. Pain after joint activity may indicate the initial development of osteoarthritis. Mild to moderate development causes more intense pain but is relieved with rest. This occurs with the wearing away of cartilage and the narrowing of the joint space. Severe osteoarthritis causes pain at rest due to the nature of osteophytic growth and possible bone on bone rubbing at this stage (Grelsamer and Loebl 1996, Michael et al. 2010, Swearingen 2007).
Today, people are exposed to a variety of treatments, from aiding the afflicted individual's pain relief on a day to day basis to total knee replacements. Home care and remedies typically involve resting the joint or applying heat or ice to swollen, stiff, or painful areas. Stretching and exercise to strengthen the joint can also be helpful. Medical treatments are the next step in relief from osteoarthritis. Over-the-counter drugs such as acetaminophen, aspirin, or non-steroidal anti-inflammatory drug (NSAID) pain relievers can be used when relief is inadequate. The final therapy is surgical intervention due to its invasive nature. Arthroscopy can be performed to remove tears and loose material in the joint or to implant cartilage. As a measure of last resort, partial or total knee replacements and prostheses are performed on older individuals who are less likely to require a repeat procedure (Grelsamer and Loebl 1996, Swearingen 2007).

Rogers and Waldron (1995) caution the relationship of pain to the severity or existence of osteoarthritis. They contend that clinical studies show that patients who complain of severe joint pain show little to no signs of osteoarthritis on those bones. Conversely, patients without symptoms have exhibited features that an osteologist would probably assign to osteoarthritis. Indeed, Hannan and colleagues' (2000) study echoes the discordance between professional diagnosis of osteoarthritis, radiographic diagnosis, and reported knee pain. Spector and Hart (1992), however, found a 40-80% correlation between knee pain and radiographic evidence. They argue that a better assessment can be made from the patella-femoral compartment of the knee, rather than relying on strictly
anterior-posterior views. Perhaps different radiographic techniques in future studies will further close this disparity between what causes pain and what changes are happening in the joint.

Lagier writes, “a suitable analysis of bone eburnation can evoke a patient of the past with a clinical picture of disability and pain, even with the perception of joint cracking during movement” (2006:130). Given all the treatments modern populations use today for osteoarthritis and related joint disorders and the prevalence that especially occurs with aging, pain is an obvious component of this disease. As the extent of the eburnation of patella #9347 indicates severe arthritis, beyond the initial stage of bone against bone mechanical stress, it is reasonable to assume the individual experienced pain typically associated with this stage of arthritic development. Since ancient people did not benefit from modern day medicine and technology to alleviate their symptoms, treatment was probably limited to rest and perhaps a walking aid, such as a cane, to shift weight from the afflicted joint. Disruption of normal activity from a pained knee would affect a broad range of tasks and motion. Assuming the spine and upper limbs were not affected, working from a stationary or sitting position would not have been hindered. In an agricultural and marine environment such as Tell Abraq, this individual may not have been able to travel great distances on foot and may have relied on items and services from others who were not physically restricted. This may be especially true if the individual experienced pain in other parts of the body (Croft et al. 1995). Although it is difficult to assign pain and disability to a
bone without soft tissue, the severity of the change in the patella warrants a good example of how osteoarthritis could have been painful.
CHAPTER 4

CASE STUDY #2: ADULT WITH A MAL-UNION FRACTURE (#1835/2557)

This chapter focuses on an individual who endured significant pain of a broken arm and dealt with the complications it would have caused as it healed out of alignment. Fractures are the most common traumatic injury. They occur across time, species, age, sex and activity (Zimmerman and Kelley 1982). At its most basic level, a fracture occurs when bone is broken, either completely or partially, when forces acting on that bone overstress its load bearing capacity and/or position in the body. Depending on the severity of the break and damage to bone and soft tissues, fractures can be quite lethal. As with this Tell Abraq individual, the fractured limb is easily recognized in skeletal collections and able to be interpreted by their fracture pattern and healing stage.

Description

Cases of healed fractures occur in a number of bones in the Tell Abraq collection. All of them have healed correctly except for the one shown in Figures 3 and 4 below, which is what makes it severe. As a means of comparison to highlight the severity of this Tell Abraq case, Figure 5 displays a normal radius. This case features a left radius (forearm bone), comprised of 4 fragmented pieces: from proximal (elbow end) to distal (wrist end), the first piece is not numbered, the second is labeled #1835, the third is #2557, and the last piece is not numbered. An area of bone is missing in the distal piece, measuring 2.09 cm in length (see Figure 3). About 8 cm from the proximal end of the bone, an
enlarged callus can be seen (see Figure 4). The callus (indicated by the arrow in Figure 4) measures 3.89 cm in maximum length and 2.77 cm in maximum width. The callus is different from other fractures because the radius healed during misalignment or mal-union, which will be discussed in greater detail later.

Figure 3. Anterior view of radius (#1835 & #2557)

Figure 4. Anterior view of radius (#1835 & #2557) enlarged at callus

The overall condition of bone surface indicates an ongoing periosteal reaction, or an inflammation of the outer-most bone layer, evidenced by the thickened smooth but pitted surface. This may indicate a generalized infection
occurring on the bone, possibly related to the fracture. It also appears that the bone healed, not only in misalignment, but also rotated. The distal end of the radius (see Figure 3) faces anteriorly or forward. Normally in this position, the radial tuberosity, or the oval-shaped knot near the proximal end, faces anteromedially (see Figure 5) (White 2000). As seen in both Figures 3 and 4, the tuberosity is facing anteriorly. Both proximal and distal joint surfaces display very little if any signs of osteoarthritis.

Figure 5. Anterior view of normal radius

Differential Diagnosis

A broken bone determined to have occurred before or at the time of death is a fracture. The callus is a definitive signature of healing, meaning the fracture occurred prior to death since the body had time to attempt to bridge the break and rebuild bone. This indicates that this individual from Tell Abraq survived long enough for the break to heal. Other types of signatures that may resemble a callus, such as osteomyelitis occur with other signs not found with fractures, such
as a cloaca. Severe periostitis may display a thickened portion of bone, but the surface is often pitted and does not usually surround the bone the way a callus encircles the fracture site.

This individual's fracture occurs approximately at the proximal one-third of the shaft and is considered a mid-shaft fracture of the radius. The callus has formed on the shaft below the neck and radial tuberosity but proximal to the mid-shaft. Proximal fractures of the radius are considered to be located proximal to the tuberosity; therefore, this is not a proximal fracture. There is no classification or naming system beyond this designation.

The fracture appears to have been transverse or oblique in type. Other types of fractures such as compression and spiral are eliminated from consideration, as these are either extremely statistically unlikely to occur on the radius or do not present the healing pattern as demonstrated in this bone. The fracture line has since healed and the strange angularity of the callus makes it especially difficult to determine the type. According to Galloway (1999), a radial fracture is more likely due to falls than direct blows. A direct blow, as in a parry, would place the radius behind the ulna, and the ulna would take the direct hit. Instead, a fall could produce enough force on the radius as the dominant bone bracing for the fall. Accidental fractures typically result in an oblique fracture which is what is likely to have happened to this individual (Ortner 2003).
Etiology

A fracture, such as we see in the Tell Abraq case, in its broadest sense means “any traumatic event that results in partial or complete discontinuity of a bone” (Ortner 2003:120). These traumatic events can be accidental, as in a fall, or intentional, as in an act of violence. Fractures are classified based on numerous factors such as severity, type of force, and predisposition to fragility. Most often, a fracture occurs when abnormal stress is placed on one or more bones (White 2000). The types of forces that can cause a fracture are tension or pulling, compression or pushing, torsion or twisting, flexion or bending, and shearing (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Galloway 1999, Waldron 2009).

Each force creates a different fracture pattern on the bone that can allow one to identify the traumatic event. First, the fracture can be incomplete or complete. An incomplete fracture means the bone is merely cracked with some of it remaining intact while a complete fracture indicates a separation into two or more pieces of a single bone element (Galloway 1999, White 2000). This case study is of a complete fracture. Second, there are types of complete fractures based on the shape of the fracture line. These are transverse, oblique, spiral, comminuted or shattered, butterfly, and segmental (Galloway 1999). In this case study, the type is a transverse or oblique fracture resulting from a bending force.

Immediately after a traumatic fracture, three natural reactions of the human body usually follow: blood loss, displacement, and pain (Waldron 2009). Whether or not the bone breaks the skin, hemorrhage from broken blood vessels
in the damaged bone and overlying soft tissues will occur. This blood may be contained internally within the broken limb until it coagulates, or it may drain from the wound externally. Displacement refers to the body’s natural reaction of muscle spasms at the fracture site. Unless adjacent bones act as a splint, these spasms tend to pull fragments further out of alignment. Considerable pain at the fracture site will occur. Movement may significantly exacerbate the pain, especially in a broken limb. We can speculate that this adult from Tell Abraq suffered extensive soft tissue damage since the radius was both fractured and dislodged from normal anatomical alignment. The pain this individual experienced during this initial phase, after his or her fall, was likely excruciating.

To begin the healing process, successful treatment of these reactions depends upon reducing and immobilizing the limb.

Reduction is the result of placing the bone back into its normal anatomical position. In modern settings, fracture patients are anesthetized, solving the problem of muscle spasms, and doctors are aided by X-rays. Prior to these medical inventions, patients would have been restrained to allow the medical practitioner to “overcome the resistance of spasmodic muscles and the patient’s natural inclination to escape from the pain” (Waldron 2009:142). We can presume the pain this Tell Abraq adult endured while attempting to reduce the fracture was extreme.

Immobilizing a fracture has been done for thousands of years through the use of splints; it is likely that Tell Abraq people also employed this practice (Waldron 2009). The immobilization period directly depends on the healing time
of the fracture, as will be discussed below. Because of muscle atrophy, it is likely that patients will need to undergo some kind of physical therapy to exercise the weakened limb and strengthen it to its normal capacity.

The normal healing process takes place in several stages, but repair begins as soon as the break occurs (Aufderheide and Rodriguez-Martin 1998, White 2000). If the fracture does not break the skin, a hematoma or bruise forms in what is called a closed fracture. The blood coagulates within 6-8 hours, stemming the bleeding from broken vessels in the bone and any muscle tissue that may have been torn. The periosteum, or outer-most layer of bone, is typically broken and sometimes stripped from the fracture site. This activates bone-forming cells to initiate the bone rebuilding process in what will become the callus. The clotting of the hematoma creates an environment that aids the bone-formation by providing a matrix for the fibrous connective tissue to begin to unite the broken ends. Within 2 days, rapid bone growth by osteoblasts along this matrix mineralizes to become woven bone. After about 1 week up to 6 weeks, the fracture is strengthened by the development of a callus. The woven bone callus is later replaced by lamellar bone, and the callus is minimized through normal bone resorption (Ortner 2003, White 2000). In the Tell Abraq bone, the callus has clearly formed, but it has not achieved the resorption stage. This means the break is at least 6 weeks old.

The rate of the healing process depends on many variables, not limited to the success of reduction and immobilization. Other factors, such as an individual’s age, health, diet, blood supply, and bone quality, can play a role in
healing time (Waldron 2009, Ortner 2003, White 2000). The only information we can glean from the radius is that this case involves an adult. Any indications of compromised healing due to the other factors mentioned previously are not supported.

Certainly, complications can arise from fractures at any point after the trauma. Most obviously, death is an expectation if the individual suffers from major blood loss or damage to a vital organ. Other complications include non-union, where the fracture fails to join and heals, infection of the soft tissues that precludes healing, and disruption or fusion of joints that create abnormal joint mechanics (Waldron 2009, White 2000, Zimmerman and Kelley 1982). This Tell Abraq individual suffered from a complication known as a mal-union, and it usually results in a usable but deformed limb (Waldron 2009). If the bone is not properly reset to its normal anatomical position or the healing bone is not properly restrained, then the ends may shift and heal at an awkward angle or position. Shortening and deformity of the limb is the eventual outcome. While this situation is not as severe as any of the other complications, it is a testament to the great healing and care that was required for this individual to survive.

Although the anatomical position of the radius allows for a greater chance of dislocation, perhaps as a means to avoid fracture (Galloway 1999), they still occur often. It is extremely likely for children to suffer forearm fractures. They account for 45% of all childhood fractures (Galloway 1999). Children become more exposed to risks involving injury to the forearm as a result of increased physical activities such as sports and increased activities independent of
supervision. As children age and the diaphysis of the bones harden and become more resistant to injury, the metaphysis becomes the site more likely to break. Young adult males have slightly more fractures than females, but the ratio shifts to females after age 45. This may be, in part, due to a sexually-biased and age-related factor, such as osteoporosis. Distal fractures tend to occur in older adults (Galloway 1999, Cox and Mays 2000). Given that we are unable to age or sex this individual from the radius alone, we can only assume this fracture happened to an adult. Adult fractures of the radius tend to be complete, occur at the shaft (the middle third), and are usually oblique or transverse (Galloway 1999). There are different names for fractures depending on bones involved, location, and sometimes severity (e.g. Galeazzi, Monteggia, etc). The lack of other associated arm bones from this individual also prohibits a more specific classification, but we can say that this type of fracture was typical for an adult from Tell Abraq.

Implications for Disability and Care of the Individual at Tell Abraq
Clinical manifestations of a fracture include the following: pain (point tenderness, increased with movement), swelling, deformity, decreased function/paralysis, crepitus (grinding noise from ends grinding together), bruising, decreased pulses, color changes, coolness, muscle spasm, numbness and/or tingling (LeMone and Burke 2004). Modern treatments of a fracture vary by its location, but the same reduction and immobilization steps are required (Swearingen 2007). Specifically for the radius, open reduction, or surgical resetting, is preferred over closed reduction (Watson 1990). This is due to
complex factors such as re-establishment of the radial-ulnar joints and of the radial bow, which is more difficult to accomplish in a closed system. For more serious ulna and radius fractures, screws and plates are a standard surgical treatment, followed by a cast and a controlled-movement brace, called an orthosis (Watson 1990). These techniques minimize the likelihood of mal-union or non-union fractures so that we would not typically see today what is shown in the Tell Abraq bone.

While the human body is incredibly resilient and most fracture cases are nonlethal, this does not diminish the effects of caretaking efforts of those who assisted trauma patients in ancient times, such as at Tell Abraq. Waldron writes, “What is particularly noticeable about fractures that are found in skeletal assemblages is that the majority are well healed and in good alignment and few are found with signs of infection. This must indicate that there were in the general community, a number of individuals who had the knowledge and the skill to treat and set broken bones, and that the community was able to care for the injured individuals during their period of recovery and recuperation” (2009:143). Ortner agrees that even without improved hygiene, awareness of infectious organisms, and antibiotics, treatment of fractures in early human societies has been remarkably good (2003).

Observably, the complications from fractures as described above are the minority, but this case study represents a healed mal-union fracture. A number of scenarios could have contributed to this instance. First, assuming the individual did not receive any treatment, the ulna could have supported the broken radius
as a splint, albeit imperfectly, and the radius healed as is. Second, devoid of surgical methods, the prehistoric bonesetter may have had difficulty reducing the fracture. If the individual was in substantial pain while the bone was being reset, he or she may not have been able to remain still for proper reduction to take place. Third, the fracture was reduced effectively but not immobilized. Use of the forearm before sufficient healing has taken place could have shifted the bones out of place. Unfortunately, it is impossible to determine what transpired to cause this mal-union, but it is easy to imagine the pain involved in each case.

In terms of disability, let us assume this individual’s left arm was likely the only incapacitated part of his or her body. If the arm was immobilized during healing, either by treating it with a splint or keeping it stationary to avoid pain with movement, any actions requiring the use of the left arm or both arms would have been affected. Impeded actions would include any type of agricultural or fishing activity and even basic functions such as feeding, bathing, and clothing oneself. Until the radius was adequately healed or revealed no painful symptoms, this individual would have needed direct care to accomplish these needs.

After the temporary term of disability during the healing stage, this individual was still left with a mal-union deformity. Clinical research shows function of the wrist and elbow joints can be seriously compromised with a healed mal-union (Watson 1990). A 2 cm difference in shortening can cause severe dysfunction (Aufderheide and Rodriguez-Martin 1998). Waldron (2009) notes that the degree of shortening and angulation of healed mal-union fractures can be measured by comparing the opposing normal limb. This is, however, an
important point that must regrettably be overlooked due to the problem of the commingled context. Although the mal-union makes it challenging to assess, the degree of development of the callus allows that this individual survived at least several weeks after the incident. This means we can expect that the individual continued to use his or her arm, but with difficulty.
CHAPTER 5

CASE STUDY #3: ADULT WITH A STRESS FRACTURE (#2680)

This chapter will focus on an individual from Tell Abraq with a different type of injury called a stress fracture. Also called “fatigue” fractures (Aufderheide and Rodriguez-Martin 1998, Hershman and Mailly 1990), they result from repeated stress on an area of bone that is enough to cause very minute damage. Over time, these tiny insults to bone integrity accumulate before there is time to heal and may create a fracture (Aufderheide and Rodriguez-Martin 1998, Hershman and Mailly 1990, Pepper et al. 2006, Waldron 2009, White 2000). If not allowed to heal, stress fractures can become painful or worsen with continued activity and develop into complete fractures. Based on our observations, we can imagine in a community such as Tell Abraq that proper care and healing of a stress fracture would be vital to continue subsistence practices.

Description

Stress fractures can occur throughout the body. They can be difficult to find archaeologically because they are generally non-lethal and heal well. The case noted in Figures 6 and 7 may be one of the only stress fracture examples in the Tell Abraq collection. The bone in the figures is a right talus (#2680) or ankle bone that fits between the tibia and calcaneus (heel) (see Figure 6). The talus measures 5.54 cm anterior-posterior and 5.41 cm medial-lateral. It appears to have been entirely covered in a lacquer or glue after excavation. Despite some
cortical damage, the bone is complete and looks healthy despite a fracture line on the inferior surface (see Figure 7). The fracture line (as indicated by the arrow
in Figure 7) measures 2.00 cm long and runs anteromedially (front and towards midline) to posterolaterally (back and away from midline) on the posterior articular facet with the calcaneus, crossing the inferior (bottom) aspect of the lateral (outside) process.

Differential Diagnosis

Stress fractures are defined as a “crack in one cortex of a bone” (Mourad 1995:19). They tend to be incomplete and heal without any evidence, which makes them underrepresented in archaeological samples (Ortner 2003). Determination between a stress fracture and an incomplete fracture is rather difficult when examining skeletal material, and so the injury must be contextualized (Ortner 2003). It is possible that this is an incomplete fracture, but there are a number of factors that decrease this likelihood. For example, incomplete fractures are more common in children, and this case represents an adult (Galloway 1999).

Fractures of this area of the talus also tend to be complete. Hawkins (1965) determined the lateral process of the talus typically fractures in 3 types, varying by extent: 1) chipping of the inferior tip from ligament tension, 2) large fragmentation of the tip, and 3) comminuted fracture of the process (Galloway 1999). This location and type of fracture is also recently known as a “snowboarder’s” fracture or ankle (Chan 2003, Galloway 1999). The fracture occurs when an individual falls and the dorsiflexed foot (flexed with the toes closest to the shin) is inverted (angled toward the medial plane). As
snowboarding is a relatively new sport, the injury is rarely found outside of individuals who participate in the activity, such as in the Tell Abraq population.

Given that the location of the fracture line is on the inferior surface (bottom), the fracture may have also been caused by a fall in which the foot was everted (angled away the medial plane). This means the calcaneus or heel bone may have likely been affected as well. Unfortunately, the talus is all there is to go by since there is no way to associate this talus with its articulated calcaneus. With the talus alone and by the location of the fracture, this Tell Abraq individual most likely was suffering from a stress fracture.

Etiology

As mentioned previously, stress fractures are the products of overuse of bones. The bone cortex becomes damaged after repeated microtrauma as opposed to a single large load that exceeds a bone’s physical threshold (Hershman and Mailly 1990). Because the bones are met with continual stress, this means that stress fractures are directly related to activity, which varies the incidence and location. The subsistence practices and activity patterns of the people of Tell Abraq make it easy to expect that stress fractures were a more common occurrence than in modern populations.

Frequency of stress fractures is particularly high in athletes due their levels of intensity and periods of physical activity (Aufderheide and Rodriguez-Martin 1998, Pepper et al. 2006, Waldron 2009). This level of activity would be common in ancient societies such as Tell Abraq. Runners, especially long
distance, have the highest incidence of stress fractures, 69% in one study of 320 athletes (Hershman and Mailly 1990). Another study of runners found the tibia and fibula are the most common sites for stress fractures (Hershman and Mailly 1990). Along with specific types of activities, other factors that can place an individual at risk for stress fractures are sex, race, and fitness level (Pepper et al. 2006). People with a previously inactive lifestyle who begin a training regimen quickly and perhaps too intensely are placed at a higher risk, such as military recruits (Hershman and Mailly 1990). Female athletes are of special consideration with respect to stress fracture frequency, due to factors such as amenorrhea, or the absence of a menstrual cycle during reproductive age, and decreased bone mineral content (Hershman and Mailly 1990). In terms of biological affinity, white and Asian women report significantly more stress fractures than African American women (Pepper et al. 2006).

The types of fractures that occur with stress are typically bending and compression. In the same concept as a bending fracture, stress fractures can occur on tensile side of the bone along cement lines or the osteon. Compression occurs with the accumulation of diffuse microfractures. The process of micro-damage from small load stresses happens faster than new bone can form and results in a fatigue fracture (Hershman and Mailly 1990, Pepper et al. 2006). This makes resting the fracture especially important to allow time to heal. Due to the needs of the society, it is unlikely that an individual with this type of injury would have taken the necessary time to permit healing.
Across activities, stress fractures in the lower extremities (especially the distal second metatarsal and calcaneus) are most commonly affected along with the upper third of the tibia (Aufderheide and Rodriguez-Martin 1998). Other common stress fracture sites are the femoral neck, distal femur diaphysis, pubic rami and lower fibula. Stress fractures of the talus are less common, but when they do occur, the lateral process is the most affected part of the bone (Wilder and Sethi 2004). While this Tell Abraq bone is not characteristically affected by stress fractures, the location of the fracture on this bone is typical.

Implications for Disability and Care of the Individual at Tell Abraq

The clinical symptoms observed today are not likely to have changed from those in Tell Abraq. The characteristic clinical symptom of a stress fracture is subtle pain localized at the site that worsens with activity (Hershman and Mailly 1990, Pepper et al. 2006). In the initial stages, pain does not occur until after activity, but as the fracture progresses, pain will occur during activity and become limiting. Other manifestations include point tenderness and swelling, but these do not usually occur. Often, the symptoms reveal themselves with a change in training, such as a harder playing surface, change in footwear, and increased activity duration or distance. Radiographs often do not reveal stress fractures, so more effective technologies such as radionuclide bone scan imaging and computed tomography (CT) scans are utilized today (Hershman and Mailly 1990).
Wilder and Sethi (2004) discuss the predisposition for talar stress fractures in the lateral process due to excessive pronation or bearing weight on the inside of the foot. A habit of pronated walking can occur with fallen foot arches and would permit repeated stress on the process from the calcaneus. An individual from Tell Abraq who walked with this tendency and who perhaps carried heavy loads, such as mud-bricks, wood, food, etc., would have been prone to this sort of stress fracture we find in the collection.

Modern treatment of this condition would involve six weeks of non-weight-bearing rest and possibly a cast to immobilize the foot or an orthotic device to correct the pronation (Hershman and Mailly 1990, Wilder and Sethi 2004). Treatment of talar stress fractures is critical because more evolved fractures are more likely to heal poorly (Wilder and Sethi 2004). For this individual, treatment of the stress fracture may have begun with extended ankle pain after a sprain. Pain from activities involving heavy loads and possibly walking would have limited this person’s ability to perform these tasks until the fracture was healed enough to where the pain subsided. Much like someone suffering from arthritis, he or she would still be relatively ambulant but probably not for long distances or periods of time. This individual could also continue to perform tasks while seated and contribute to subsistence via other activities.
CHAPTER 6

CASE STUDY #4: ADULT WITH A DISLOCATION WITH OSTEOARTHRITIS (#4526)

This chapter investigates a Tell Abraq individual who suffered a possible knee dislocation. With this type of injury, this adult would have been dependent on other members of the community, but it is apparent that this individual continued to work out of necessity despite the discomfort. The evidence lies in extensive eburnation on the articular surface of a femur, a diagnostic sign of osteoarthritis, which is known to occur as a consequence of a poorly healed fracture or a dislocation over time (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Waldron 2009). Although dislocation of the knee is rare, complications from ligament, tendon, or muscle tears can place this joint at risk. Once a dislocation occurs and is left untreated, pain from the injured joint often ensues.

Description

This case appears to present trauma-related osteoarthritis of a left femur (#4526). The femur is missing its very proximal end, but the part of the bone of interest is relatively complete, save for part of cortex missing from the distal anterior and medial surfaces, as can be seen in Figures 8 and 9. The distal joint surface measures a maximum of 9.35 cm medial-lateral and 6.80 cm anterior-posterior.
Extensive eburnation combined with some pitting is evident on the distal articular facet with the proximal tibia, known as the medial condyle (see Figure 8 and Figure 9).
This polished patch (indicated by the arrow in Figure 10) measures a maximum of 4.77 cm in width and 5.46 cm in length. Interestingly, the pattern of eburnation grooves run anterior-posterior on the posterior portion of the condyle and then curve posteromedially to anterolaterally (about 45 degrees) along the shape of the anterior edge of the condyle. Osteophytes are also seen on the marginal edges of the medial aspect (see Figures 8 and 9) as well as the intercondylar notch (see Figure 10).

Figure 10. Inferior view of femur (#4526)

Differential Diagnosis

Based on the case of severe osteoarthritis that was previously explored, this example also presents a definitive form of osteoarthritis in Tell Abraq. Pitting,
eburnation, and osteophytes are all diagnostic features of degenerative joint disease (Jurmain 1999, Waldron 2009, Rogers and Waldron 1995). Because eburnation is rarely found in skeletal samples, the femur could be afflicted by severe degenerative osteoarthritis, but this is rather unlikely. Rogers and Waldron (1995) found that the incidence of osteoarthritis of the patellofemoral aspect is three times that of the tibiofemoral aspect, the latter of which is represented in this case. The sheer amount of eburnation on the medial condyle, however, coupled with the curvature of the grooves suggests a dislocation with traumatic origination (Aufderheide and Rodriguez-Martin 1998, Ortner 2003).

The femur itself does not appear to have been involved in a traumatic injury, since there is no sign of healed fracture or the like. Dislocation, however, can lead to premature degeneration of a joint due to the abnormal biomechanical loading and functioning (Ortner 2003). One way the knee can be misaligned is by tearing or rupture of the ligaments. In particular, the anterior cruciate ligament (or ACL) is one of which is susceptible to damage through activity. The ACL “prevents excessive forward motion and internal (medial) rotation of the tibia” (Swearingen 2007:652). The curved grooves we observe on the articular facet of this individual’s bone suggest repetitive grinding of the tibiofemoral joint during an inward rotation of the dislocated knee as the leg was straightened.

Etiology

Dislocation is defined as the “disruption of the normal relationship between the bony (and the associate articular cartilage) components of a joint” (Ortner
This entails complete or partial loss of normal contact between joint articular surfaces. The medical term is luxation, or subluxation which denotes a less severe characterization. The most common cause of this disruption is traumatic injury which may include tearing of the connective tissue capsule enclosing the joint, and any muscles, tendons, ligaments, nerves, and vascular supply associated with it (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Swearingen 2007). The severity of a dislocation depends on joint involved and the degree of dislocation and its duration (Aufderheide and Rodriguez-Martin 1998).

Some joints are more vulnerable to dislocation than others. The shoulder and hip joints are the most commonly affected, yet examples of dislocations are rare paleopathologically (Aufderheide and Rodriguez-Martin 1998, Ortner 2003). Ortner (2003) cites a Nubian population of several hundred with one hip dislocation. This prevalence may be skewed because in order to identify a dislocation in an archaeological collection the dislocation had to have endured long enough for bone to remodel and produce a visible anatomical change (Aufderheide and Rodriguez-Martin 1998, Ortner 2003). Persistence of the dislocation produces the more long-term changes of accelerated degenerative joint disease, like the eburnation we observe in the Tell Abraq individual.

Although knee dislocation is not very common, the knee is a very complex and unstable joint prone to sprains. Knee ligaments, tendons, and muscles are the only structures stabilizing the joint. Falls, pivoting, twisting, and overextending the knee joint are all actions that could tear these elements, and in particular, the
ACL (Frontera et al. 2008). Modern ACL injuries happen more often in women than men when compared in the same activity, due to strength imbalance in the leg muscles (Frontera et al. 2008). We cannot determine if the Tell Abraq femur is male or female, but we can assume that ACL injuries occur today much like they did in the past.

**Implications for Disability and Care of the Individual at Tell Abraq**

In a typical dislocation and also at Tell Abraq, clinical symptoms vary by joint but include significant pain and loss of normal joint mobility (Swearingen 2007). Modern management of dislocations requires immediate reduction, often with the aid of NSAID (non-steroidal anti-inflammatory drug) pain relievers and sometimes anesthesia. Immobilization may be needed for up to 8 weeks until pain from movement subsides and/or muscle function returns.

Ligaments are related to dislocations because they enhance joint strength by connecting bones (Swearingen 2007). A joint can have several ligaments, each reinforcing different planes of movement. Ligament tears are much like fractures. They occur when stress on the ligament either pulls it in an abnormal direction or exceeds its strength. Ligaments tears even share fracture types, i.e. transverse, longitudinal, complete or incomplete. Patients often complain of pain, joint weakness, tenderness, limited range of motion, and ambulatory difficulty. The standard “RICE” treatment applies for lesser tears: ‘R’esting the joint, application of ‘I’ce to reduce inflammation, ‘C’ompression to inhibit swelling, and ‘E’levation of the affected part (Swearingen 2007). It is unknown whether
knowledge of these treatments was possibly employed by caretakers at Tell Abraq, but the obvious symptom of pain would likely have necessitated plenty of rest of the affected knee.

Clinical accounts of individuals with ACL tears report a feeling of the knee buckling, giving way, or otherwise becoming unstable (Swearingen 2007). Sometimes a pop is heard or the tear is felt. Certain physical tests along with x-ray and MRI can be performed to determine the extent of the injury. When the standard treatment is ineffective or the tear is complete, surgery is highly recommended and effective, especially for those who wish to continue to be active or who have recurrent issues with joint instability. This Tell Abraq individual, however, likely knew the instant when the ligament was torn, but because ancient medicine most likely did not develop joint surgery, an ACL tear would have been left untreated.

This condition would have created an insecure knee joint and eventually developed osteoarthritis (Swearingen 2007). A possible behavior that would place this individual at risk is heavy lifting. Strong compressive forces exist in the tibiofemoral joint when performing actions such as a squat or any large weight-bearing (Escamilla 2001, Meyer and Haut 2005). Meyer and Haut (2005) found that compressive loads on the knee would cause displacement and rotation of the tibia. Successive repetitive loading in this manner would result in injury to the ACL. At Tell Abraq, heavy loading of items such as agricultural or marine resources, mud-bricks, wood, etc. come to mind as probable scenarios in which an ACL tear could occur.
If this individual suffered a knee dislocation in conjunction with an ACL tear, pain at the onset of the injury would almost certainly be extreme. As the joint would swell, the knee would likely need to be rested or immobilized. Depending on the severity of the tear, once the ligament began to heal, she or he would resume ambulatory function and her or his lifestyle, however, not easily. This individual's knee is highly polished, meaning he or she lived with a rotation or dislocation for a long time. As muscles strengthened and ligament healed around the joint, this tenderness would have been relieved. Much like other cases that limit travel, this person was likely restricted to short distances if the joint hurt. Otherwise, the knee was used considerably as shown by the eburnation and grooves on the joint surface.
CHAPTER 7

CASE STUDY #5: ADULT WITH OSTEOMYELITIS (#11579)

This chapter concerns a Tell Abraq individual with osteomyelitis, an infection involving a bone and its marrow cavity. Osteomyelitis is considered a secondary complication due to its etiology. The infection begins as a result of perforation of the skin that contracts pus-forming bacteria. The bacteria either infest the site of the opening and then affect the bone or spread to other parts of the body through the bloodstream (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Waldron 2009, White 2000). Since this initially affects soft tissue, paleopathologists are only able to discern signs of the infection when it progresses to affect the bone. These signs are rather distinct and indicative of a serious and painful condition. Despite modern medical advances like antibiotics, osteomyelitis is still a threat to contemporary populations.

Description

Very few bones in the Tell Abraq collection show signs of osteomyelitis, but the case noted in Figures 11 and 12 is classified as the most severe in the small sample. The afflicted bone is a fragmented shaft of a right tibia, or shin bone (#11579) (see Figure 11). The fragment occurs in the distal third of the shaft and measures 11.74 cm in total length and 2.62 cm medial-lateral. Cracks in the bone appear to be post-mortem taphonomic damage that has been previously glued together. The most glaring property of this fragment is the elongated “hole” (indicated by the arrow in Figure 12) exposing the medullary
cavity near the anterior or front surface. This opening or cloaca measures 3.82 cm long and 0.48 cm wide and exhibits a rounded, blunt edge into the cavity.

Figure 11. Anterior view of tibia fragment (#11579)

Figure 12. Anterior view of tibia fragment (#11579) enlarged at cloaca
The cortical thickness (the amount of bone between the inner layer or marrow cavity and the outer layer) is significantly reduced at the distal end of the fragment compared to the proximal end. Additionally, the periosteum, or outermost bone layer, has a dried, flaky appearance and texture with some thin layers stripped off, creating a patchy and discolored surface.

Differential Diagnosis

Osteomyelitis is a disease that affects bone and its inner marrow cavity. The two unique diagnostic features of osteomyelitis determined by paleopathologists is a drainage canal from the marrow cavity (which is the cloaca we observe) and sequestered bone associated with new periosteal formation (called sequestrum and involucrum, which is not the case here) (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Waldron 2009, White 2000). Additionally, because the fragment is from the distal third of the tibia, the thin cortical bone may be a weakened area near the distal metaphysis, which is a common location for blood-borne bacteria to settle and develop osteomyelitis (Ortner 2003). Ortner (2003) comments that the mature and developed periosteum of adult long bones, such as this Tell Abraq tibia, inhibits stripping of this layer, which may account for its flaky appearance. As we see in this Tell Abraq bone, osteomyelitis in adults is less acute and less extensive than cases in children.

Given that this case involves a tibia with a cloaca, it is certainly possible this represents an adult male with osteomyelitis. Waldron (2009) provides an example of adult osteomyelitis through open fractures. In both contemporary and
ancient groups, 3-25% of open fractures become infected (Waldron 2009). He attributes high rates of infection to young men who engage in sports or hazardous activities, with the tibia as the most commonly affected area.

Etiology

As mentioned above, osteomyelitis is an infection of bone (osteitis) and bone marrow (myelitis) (Aufderheide and Rodriguez-Martin 1998). The infection originates from bacteria that enter the body through broken skin, typically from an open fracture related to trauma or surgery. The most common bacterium that contaminates the wound is *Staphylococcus aureus*, which accounts for 90% of cases (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Waldron 2009, White 2000).

The bacteria then affect the bone either directly or indirectly (Aufderheide and Rodriguez-Martin 1998, Lewis et al. 2000, Ortner 2003, Waldron 2009, White 2000). A direct infestation occurs at the site of the open wound. Indirect infection comes about when the bacteria travel through the blood stream, which is why it also called hematogenous. Hematogenous is the most common type, followed by direct infection from a traumatic injury (Aufderheide and Rodriguez-Martin 1998). The disease is also classified by duration; acute osteomyelitis is more common and typically lasts less than 1 month while chronic cases can continue to infect intermittently for years (Lewis et al. 2000, Swearingen 2007, Aufderheide and Rodriguez-Martin 1998, Waldron 2009). Because this Tell Abraq individual’s case is only represented in a tibia fragment, we cannot ascertain whether the
Osteomyelitis was acute or chronic; however, we can assume the infection was caused indirectly since the fragment does not appear to have been fractured.

In either form or entry, the bacteria filter into the marrow cavity as well as the microscopic channels (called Haversian canals) in the bone cortex and subperiosteal spaces (Aufderheide and Rodriguez-Martin 1998, Waldron 2009). The bacteria produce pus which creates pressure inside the bone and is thus called suppurative or pyogenic osteomyelitis (White 2000). This pus and pressure obstructs normal vascularization in the bone, and the cells that do not receive appropriate nutrients die. Channels in the dead bone relieve the pressure within either by creating more space in the medullary cavity or forming a cloaca. Due to the presence of the cloaca and the thinned cortical bone, both forces were at work within this Tell Abraq adult’s shin.

Osteomyelitis is known to occur around the world. The hematogenous form most often afflicts children between ages 3-12, when bone growth and formation is most active (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Waldron 2009). In adults as mentioned previously, osteomyelitis is 2-4 times more likely in males, probably due to greater exposure to trauma (Aufderheide and Rodriguez-Martin 1998, Ortner 2003). Aufderheide and Rodriguez-Martin (1998) also write that osteomyelitis has a high rate of incidence in debilitated individuals and in injured bones. These prevalences lend support that this Tell Abraq adult was likely a male who suffered a broken bone and developed osteomyelitis.
Implications for Disability and Care of the Individual at Tell Abraq

Despite antibiotic treatments, current clinical settings still encounter osteomyelitis, which allows us to apply modern incidents to Tell Abraq. Systematic symptoms involve fever, chills, night sweats, malaise, restlessness, nausea, and increased heart rate. The localized symptoms exhibited are severe bone pain (unrelieved by rest and worse with activity), swelling, tenderness redness and/or warmth of the skin, and decreased range of motion in adjacent joints (Lewis et al. 2000, LeMone and Burke 2004, Mourad 1995). Signs of advanced infection include drainage from sinus tracts to skin and fracture site.

Anyone at any age may contract osteomyelitis, such as from a Staph infection, but certain contemporary groups are particularly at risk. These individuals comprise of the elderly, immunocompromised, malnourished, diabetics, or those who have had a recent history of trauma, biopsy, surgery, or sepsis (Lewis et al. 2000, LeMone and Burke 2004, Swearingen 2007). Of these groups at risk, we can speculate the Tell Abraq adult may have recently suffered a traumatic injury. Modern patients are treated immediately with antibiotic therapy which is usually successful. Drug-resistant bacteria, however, such as MRSA (methicillin-resistant Staphylococcus aureus) have limited clinical treatment of osteomyelitis (Lewis et al. 2000). In more progressed cases or when antibiotic treatment is unsuccessful, surgery is the next option, followed by amputation (Lewis et al. 2000, Swearingen 2007, Waldron 2009). Amputation would likely have been practiced at Tell Abraq, but this individual’s case had not progressed to the point of its necessity.
Because the duration of the infection depends on the bacteria’s virulence coupled with the host’s resistance, there are various survival conditions associated with osteomyelitis. Before modern treatment, the mortality rate for people who contracted osteomyelitis was at least 20% (Ortner 2003). The other 80% who survive the disease do so for years and, since the majority of cases happen to children, often into adulthood (Waldron 2009). This means different forms of acute and chronic manifestations occur archaeologically.

Without a complete skeleton or even a complete tibia, it is difficult to determine if this Tell Abraq individual was battling acute osteomyelitis or another chronic episode from a childhood infestation. Two situations could have taken place to produce the evidence found in this tibial fragment. This individual could have survived an acute form of osteomyelitis, and the tibia was healing when something else could have killed him or her. The healing process, however, takes longer in both infected hard and soft tissues, and may cause some deformity. Thus, the more likely circumstance is that this adult died from this case of osteomyelitis.

Before death, this individual would have been in severe pain in his or her lower leg. Walking or standing would have been extremely painful or difficult, especially before pus drainage could bring some relief. It would have been necessary to immobilize the leg to reduce pain and prevent the weakened bone from fracture. This condition would severely limit physical activity, at least during its acute phase of infection or if it was contracted from a traumatic injury. In the case of chronic osteomyelitis, the initial infection and its systematic symptoms
such as fever and malaise would potentially only affect activity as would any other viral or bacterial illness.
CHAPTER 8

CASE STUDY #6: ADULT WITH SPONDYLOSIS DEFORMANS (#25550)

This chapter examines a Tell Abraq individual with spondylosis deformans. This disease is generally associated with intervertebral disc degeneration. With age, normal wear and tear, and compression and decompression, the vertebral discs eventually become less elastic and more prone to tearing and herniation. As they change, so do the vertebral surfaces that they cushion. Typically, the bone reacts by generating bone spurs or osteophytes as the periossteal layer becomes exposed and irritated (Aufderheide and Rodriguez-Martin 1998). This disease can worsen as osteophytes continue to proliferate and increase in size, in extreme cases, leading to fusion and limited mobility of the spine. Progression of the disease would require outside care and support as the afflicted individual became less flexible.

Description

This case presents a peculiar lumbar (L-3) vertebra (#25550), as seen in Figure 13. The bone is mostly complete, missing only the transverse processes and spinous process that flare laterally and posteriorly, respectively, from the neural arch that surrounds the spinal cord. The rounded shaped in the anterior region, or vertebral body, measures 5.90 cm anterior-posterior, 3.91 cm in width and 2.64 cm in height. The largest distinguishing feature that indicates this bone is not normal is the bulbous growth on the anterior surface of the vertebral body (see Figures 13, 14, and 15). The growth (indicated by the arrow in Figure 13)
measures 2.31 cm anterior-posterior, 2.81 cm in width, and protrudes 1.87 cm anteriorly from the margin.

Figure 13. Anterior view of lumbar vertebra (#25550)

Figure 14. Superior view of lumbar vertebra (#25550)
This excessive bone formation, or osteophyte, extends superiorly across the intervertebral disc space. The superior end looks as if it were broken or damaged postmortem so it is unclear if this portion may be been fused with other osteophytic growth from the previous vertebra. Other osteophyte growth on the anterior margins is apparent and more pronounced on the right side, but it does not clearly resemble bony spurs. This may also be due to taphonomic exposure and damage. In all likelihood, this Tell Abraq adult’s spine was fusing to other vertebral elements.

Some but very little pitting is observed on the superior and inferior surfaces of the vertebral body. The inferior surface is slightly concave while the superior surface is smooth and flat. A circular pit nearly centered on the superior surface appears to be a Schmorl’s node, a pressure indentation precipitated by a
herniated intervertebral disc (Rogers and Waldron 1995). While disc herniation can be a very painful ailment, the presence of this node does not mean this individual necessarily suffered from it.

Differential Diagnosis

Although the vertebra has excessive bony overgrowth that extends vertically (in this case, superiorly) from the body, there is no direct evidence of fusion with the previous vertebra in this individual's spine. If we were to assume there was fusion, other forms of vertebral fusion such as DISH (diffuse idiopathic spinal hyperostosis) and ankylosing spondylitis tend to display differently, such as the candle wax-like appearance in DISH or the “bamboo spine” in ankylosing spondylitis, which is not observed here (Rogers and Waldron 1995). Thus this most likely is a case of spondylosis deformans. This disease goes by many names: degenerative vertebral disease, vertebral osteophytosis, marginal spondylosis, and spinal osteoarthritis (Ortner 2003, Aufderheide and Rodriguez-Martin 1998). It is expressed through osteophyte growth on the margins of the vertebral joints, which can greatly vary in shape and size and eventually lead to fusion of adjacent vertebrae (Aufderheide and Rodriguez-Martin 1998, Rogers and Waldron 1995). Degeneration of the vertebral discs may also cause pitting, and although discs may be deteriorating, the bone reaction is more hypertrophic than destructive (Aufderheide and Rodriguez-Martin 1998, Ortner 2003). The Schmorl’s node may be related to this degeneration. They are common in the lower thoracic and lumbar segments of the spine, but they are not typically
associated with spondylosis deformans. The presence of both the nodes and the osteophytic growth, however, fit this case of the Tell Abraq adult.

Etiology

As one of the names suggests, osteophytosis is the main reaction of this disease. It begins by the narrowing of spaces between vertebral bodies as the discs deteriorate and become reduced in thickness (Aufderheide and Rodriguez-Martin 1998). Contact from movement at the margins of the bodies irritates the periosteum and initiates osteophytic growth. Not surprisingly, this growth is most common on the margins of the bodies of vertebrae that are more involved in activities (Aufderheide and Rodriguez-Martin 1998, Rogers and Waldron 1995). These are the lower cervical and lower lumbar vertebrae, the latter of which is involved in this Tell Abraq individual.

The osteophytes start by growing horizontally but can turn vertically as they grow in size (Rogers and Waldron 1995). They may also be a result of ossification of the ligaments or paravertebral connective tissue that support the spine superior-inferiorly. While there is no standard scoring system, most classifications of spondylosis deformans follow similar criteria (Aufderheide and Rodriguez-Martin 1998, Kahl and Smith 2000, Lovell 1994). The lowest score is typically used for slight lipping on the margins of the body, followed by a moderate score for more pronounced lipping. Severe is scored when extensive lipping occurs with spurs, with fusion marked as extreme. Both the shape and
severity of the osteophytic growth on this Tell Abraq adult’s vertebra classify as severe.

Archaeologically, degeneration of the vertebrae is one of the most commonly seen pathologies (Aufderheide and Rodriguez-Martin 1998). Signs of slight spondylosis deformans are usually found in individuals aged over 40 years, and the severity and prevalence increases with age (Aufderheide and Rodriguez-Martin 1998, Ortner 2003, Rogers and Waldron 1995). Despite the similarity in prevalence, spondylosis deformans may or may not be associated with osteoarthritis (Rogers and Waldron 1995). Since we observe a severe case, we can assume this individual was an older adult.

Implications for Disability and Care of the Individual at Tell Abraq

As expected, spondylosis deformans and degeneration of intervertebral discs seems to naturally occur with age. The incidence and severity in the lower vertebrae, however, have also been attributed to the consequence of bipedalism and carrying upper body weight on the spine (Kahl and Smith 2000). Studies have also determined that behaviors that involve continual compressive loading of the spine and the location of the carried load also play a role (Lovell 1994, Kahl and Smith 2000, Bridges 1992). When weight is carried on the head, as in ancient Asian groups, cervical osteophytosis is often found. Tumpline use in Native American groups east of the Mississippi has been ascribed to the growth pattern of lumbar and cervical osteophytes, while groups west of the Mississippi
have a lumbar and thoracic pattern, probably from the use of both baskets and tumplines (Kahl and Smith 2000).

Kahl and Smith (2000) assessed spondylosis deformans in 42 individuals from ancestral Pueblo sites by age, sex, and severity. Outside of one instance of fusion, a severe score on lumbar vertebrae was only found in about 20% of both males and females aged 50 years or older (with sex difference not statistically significant). Similarly, Lovell’s (1994) study of spinal osteoarthritis in Harappa indicates 20% of all observed lumbar vertebrae were scored as severe with comparable remodeling. According to these scoring systems, the Tell Abraq case would likely have fallen in this category. This means that fusing spondylosis deformans is the most extreme form, which cannot be determined in this individual. Thus, a conservative score of severe would place this individual among 20% of spondylosis deformans cases.

Much like osteoarthritis, assigning pain to severity is nearly impossible. Sokoloff (1976:122) writes, “Vertebral osteophytes in the lumbar spine are so frequent that it is difficult to know whether their presence in any given individual with backache is satisfactory evidence for their contributing clinical discomfort.” But as noted previously, lower back pain has afflicted humans since we began walking upright.

Contemporary treatments of backache and stiffness include use of NSAID pain relievers and muscle relaxants, application of heat or ice to loosen muscles and reduce inflammation, and rest on a firm surface to minimize flexion of the spine and support normal curvature (Swearingen 2007). Archaeologically, any
sort of positioning to relieve pain or discomfort was likely employed. While back pain can be debilitating, it is likely that because this case is considered severe, this individual encountered back pain and stiffness but was not completely disabled. Rest after an acute episode of pain would allow him or her to return to daily life as normal. The frequency and duration of these episodes are what would affect this individual’s reliance on care from others. Severe pain would inhibit most movement, especially standing or walking. Sitting or slouching may or may not be painful.

As a final note, a comparison of vertebral osteophytosis between Tell Abraq and Lovell’s (1994) Harappan sample would prove very interesting. Archaeological evidence suggests that Tell Abraq and Harappa were in contact through trade goods. Exchange of goods and cultural ideas may have influenced lifestyle habits such as how heavy loads were carried in daily routines. The commingled remains from Tell Abraq, however, would preclude an analysis of prevalence by age and sex.
CHAPTER 9

DISCUSSION AND CONCLUSIONS

Potentials of Bronze Age Health Care

Although there is no direct evidence of the cultural medical practices at Tell Abraq, we can glean from other regions contemporary knowledge and applications of health care. Tell Abraq was a part of the trade network between Mesopotamia, Harappa India, Egypt, and other parts of the Mediterranean where the cultural exchange of goods as well as ideas was clearly apparent. From prehistoric time, knowledge of anatomy and internal workings of the body were attained by hunting and killing of animals, accidental and combat trauma, and cannibalism. Prior to the Bronze Age, medicine was explained by superstitious notions and practiced with crude traditions. Stone Age technology in India shows implements for incision, trepanation, blood-letting, scarification, and amputation (Ray 1970). Common treatments included baths, cauterization by fire, limited herbal usage, diet, and massage, each of which was accompanied by ritual surgery, spells, offerings, or prayers. Diseases were thought to be caused by external agents such as spirits and demons as a consequence to sorcery or breach of taboo (Arnott 1996, Magner 2005, Ray 1970).

These methods and beliefs were carried into the Bronze Age and later. Physicians were largely priests, magicians, and herbalists. The social elite in Egypt and the Aegean employed dedicated healers to attend to the royal families (Arnott 1996, Magner 2005). Although some physicians were trained through observation and practice in living individuals, those without some basic
anatomical knowledge based their diagnoses on signs deemed through astrology, dreams, trances, and other forms of divination. This primitive medicine, however, was not completely devoid of rational science and proper treatments. It is in the Indian Bronze Age when more diverse resources and diets were consumed to improve health and isolation of the sick was implemented (Ray 1970). Greek and Egyptian surgeons of the Late Bronze possessed skills beyond the knowledge of simple bone setting. Healed fractures are found in human remains that could not have possibly healed so well without advanced reduction and immobilization techniques (Arnott 1996).

Bronze Age pharmacology is another aspect of medical care that may have been shared within the trade network. Evidence of poppy seeds and opium use, however, does not appear in the eastern Mediterranean until the late Bronze Age. The Sumerians of Mesopotamia were known to cultivate poppies for opium at the end of the third millennium B.C. (Brownstein 1993). Widespread usage of opium in the Mediterranean does not occur for another 1000 years. Portrayals of the poppy plant are found at the Greek palace of Knossos in Crete and on juglets in Egypt circa 1600 B.C. (Arnott 1996, Kapoor 1995). Opium contains morphine and when used produces analgesic and euphoric effects in the body along with drowsiness and an elevated pain threshold (Kapoor 1995). Opium use would prove indispensible in the lives of afflicted people at Tell Abraq. Unfortunately, there is no evidence of the poppy plant or descriptions or portrayals of its use at Tell Abraq. Strictly by the dates mentioned above, it is possible that opium use
had not yet been practiced or developed in this region of Arabia, and the people of Tell Abraq lived before they would have had access to this pain relief.

Similarly, broader medical documentation from other regions occurs after Tell Abraq’s Bronze Age. Herodotus and Homer detail accounts of Greek and Egyptian medical practices, but they lived 1000 years or more after the Bronze Age inhabitants of Tell Abraq. In Mesopotamia, Hammurabi and his code of laws, some of which refer to illness and medical malpractice, lived after 1800 B.C. The few preserved Egyptian medical papyri, the earliest of which dates to 1900 B.C., describe treatments for fractures, dislocations, bites, tumors, ulcers, and abscesses in addition to formulas for prescription drugs and remedies for gynecological conditions (Magner 2005). It is indeterminable how much of this knowledge was recognized by the people at Tell Abraq, but despite the lack of evidence of surgical tools and historic medical texts, a basic awareness of diseases, treatments for trauma, and herbal remedies was indeed established.

Findings in a Broader Scope

By examining these case studies in detail, hints of care and compassion in Tell Abraq have been revealed. While many of the maladies were not life-threatening, they evoke painful images especially when viewed through a clinical lens. Modern medical treatments have evolved since Bronze Age Tell Abraq, but ancient treatments would have been practiced for the same result: alleviation of pain and recovery to normal daily life habits. We can imagine the plight of these individuals who endured pain, possible loss of social standing, and a bleak
outlook on their survival. It is, of course, entirely possible that these individuals recuperated to either resume their former roles in the community or were productive through other tasks within their abilities. These survival outcomes would not have been possible without the help of outside community members, whether it be through direct caretaking of injuries or provisioning of basic needs like food and clothing. Based on these findings, we can conclude that these members of the Tell Abraq community were valued despite the fact that they were unable or limited in their ability to contribute to the community and may even have placed a burden on the group’s resources. The people of Tell Abraq showed compassion and a caring nature toward their own, regardless of what misfortune fell upon their lives. This says a lot about the character of this culture.

This research has not aimed to display individuals who were healing and/or immobilized as helplessly disabled. It is quite possible that these individuals were involved in contributing to or compensating the community in other ways. Roles and occupations at Tell Abraq did not mean they were strictly limited to physical labor. For the time any individual was immobile, whether it was temporary or permanent, he or she could have participated in other capacities unrelated to fishing and farming, such as that of a political or spiritual figure, a teacher, or a caretaker. By including these social divisions, we can begin to appreciate the richness and diversity of the people of Tell Abraq beyond the usual lines of gender and economic function.

The findings of this research open up the new area of the “bioarchaeology of care” as pioneered by Oxenham and Tilley (2009, n.d.). This research applies
this approach in a novel way by using bioarchaeology to provide the context to an individual living at Tell Abraq as well as incorporating modern medical knowledge to understand how an individual was affected by different pathological cases. This project improves our knowledge of Bronze Age Arabia in the fields of bioarchaeology, paleopathology, cultural practices, and prehistoric medical care, and broader concepts of the origins of care and compassion are also enhanced. As a tool for analysis of commingled remains or isolated cases, this cross-disciplinary approach is one that should be considered by other researchers to better interpret skeletal remains anywhere.

Future Research

Future extensions of this research would explore the possibility of pharmacological substances in the Bronze Age Arabian peninsula. Use of possible analgesics from native plants such as khat and opium would present an earlier hallmark that is currently known to exist later in time. Testing for archaeological evidence such as seeds and internal vessel coating would prove valuable in this aspect. Differential treatment of individuals may also provide insight into the status of those buried in the tomb. It is clear that extreme cases of disease and injury are not common among the Tell Abraq collection. A disparity in healed versus unhealed pathologies, such as set versus unset fractures may reveal itself through further investigation. By accounting for the exact locations, or proveniences, of the bones with severe pathologies within the tomb, we may discover gaps in status that we cannot assess through traditional categories such
as sex and age. Both of these areas would provide a richer context of life at Tell Abraq in the Bronze Age.
REFERENCES CITEd

Arnott, Robert

Aufderheide, Arthur C., and Conrado Rodriguez-Martin

Bass, William M.

Bridges, Patricia S.

Brownstein, Michael J.

Centers for Disease Control and Prevention

Chan, G. M.

Cox, Margaret, and Simon Mays

Croft, Peter, Kelvin Jordan, and Clare Jinks

de Waal, Frans
Dettwyler, K. A.

Digangi, Elizabeth A., Jonathan D. Bethard, and Lynne P. Sullivan

Escamilla, Rafael F.

Frontera, Walter R., Julie K. Silver, and Thomas D. Rizzo

Galloway, Alison, ed.

Goldstein, Marcus S.

Gracia, Ana, Juan Luis Arsuaga, Ignacio Martinez, Carlos Lorenzo, Jose Miguel Carretero, Jose Maria Bermudez de Castro, and Eudald Carbonell

Grelsamer, Ronald P., and Suzanne Loebl, eds.

Grupe, Gisela

Gutierrez, Melinda
Hannan, M. T., D. T. Felson, and T. Pincus  

Hawkey, Diane E.  

Hawkins, Leland G.  

Hershman, Elliott B., and Todd Mailly  

Hublin, Jean-Jacques  

Jamison, Jennifer R.  

Jurmain, Robert  

Kahl, Kirsten E., and Maria Ostendorf Smith  

Kapoor, L. D.  

Keenleyside, Anne  
Kelley, Marc A., and Mahmoud Y. El-Najjar

Lagier, R.

LeMone, Priscilla, and Karen M. Burke

Lewis, Sharon M., Margaret McLean Heitkamper, and Shannon Ruff Dirksen, eds.

Lovell, Nancy C.

Magnier, Lois N.
2005 A History of Medicine, 2nd ed. Taylor and Francis Group.

Mankin, H. J., and E. Radin

McGrew, W.C.

Meyer, Eric G., and Roger C. Haut

Michael, Joern W.-P., Klaus U. Schluter-Brust, and Peer Eysel

Molnar, Petra, Torbjorn P. Ahlstrom, and Ido Leden
2009 Osteoarthritis and activity – an analysis of the relationship between
eburnation, musculoskeletal stress markers (MSM) and age in two Neolithic hunter-gatherer populations from Gotland, Sweden. 
International Journal of Osteoarchaeology 21: n/a doi: 
10.1002/oa.1131.

Mourad, Leona

O'Connell, Sanjida M.

Ortner, Donald J.

Oxenham, Marc F., Lorna Tilley, Hirofumi Matsumura, Lan Cuong Nguyen, Kim Thuy Nguyen, Kim Dung Nguyen, Kate Domett, and Damien Huffer

Potts, Daniel T.

Pepper, Michelle, Venu Akuthota, and Eric C. McCarty

Ray, Priyadaranjan

Rogers, Juliet, and Tony Waldron
1995 A Field Guide to Joint Disease in Archaeology. Chichester: John Wiley & Sons Ltd.

Silk, Joan B.
Sokoloff, Leon

Spector T. D., and D. J. Hart

Stedman, Thomas Lanthrop

Swearingen, Pamela L., ed.

Temple, Daniel H.

Tilley, Lorna, and Marc F. Oxenham

Trinkaus, Erik

Waldron, Tony

Watson, J. Tracy

Weiss, E., and R. Jurmain

White, Tim D.
Wilder, Robert P., and Shikha Sethi  

Wood, James W., George R. Milner, Henry C. Harpending, and Kenneth M. Weiss  

Zimmerman, Michael R., and Marc A. Kelley  

Zivanovic, Srboljub  
VITA
Graduate College
University of Nevada, Las Vegas
Jamie D. Vilos

Degrees:
Bachelor of Arts, Anthropology, 2002
Illinois Wesleyan University

Special Honors and Awards:
Graduate & Professional Student Association Grant, University of Nevada, Las Vegas ($450) Mar 2011
Graduate Assistantship, University of Nevada, Las Vegas ($5,000) Aug 2010
Graduate & Professional Student Association Grant, University of Nevada, Las Vegas ($600) Jul 2010
Graduate & Professional Student Association Grant, University of Nevada, Las Vegas ($550) Jan 2010
Graduate Assistantship, University of Nevada, Las Vegas ($10,000) Aug 2009
Graduate Assistantship, University of Nevada, Las Vegas ($5,000) Jan 2009

Publications:

Thesis Title: Bioarchaeology of Compassion: Exploring Extreme Cases of Pathology in a Bronze Age Skeletal Population from Tell Abraq, UAE

Thesis Examination Committee:
Chairperson, Debra L. Martin, Ph. D.
Committee Member, Jennifer Thompson, Ph. D.
Committee Member, Alan Simmons, Ph. D.
Graduate Faculty Representative, John Curry, Ph. D.