

OCCURRENCE OF DEGENERATIVE JOINT DISEASE IN THE RADIUS: ANALYSIS
OF SKELETAL REMAINS FROM THE POOLE-ROSE OSSUARY

A Thesis

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Master of Arts

in

The Department of Geography and Anthropology

by
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B.A., Baylor University, 2000
May 2002

ACKNOWLEDGEMENTS

I would like to acknowledge most importantly the enduring love and unfailing financial and emotional support of my parents Rex and Chris Parks. From their example and encouragement, I have learned leadership, discipline, contentment, how to laugh and be a family, and that there are no limits to what you can accomplish in life. Thank you for believing in me. To my sister Stacy, I have missed you! Thanks for making me laugh at times when I thought I couldn't.

To my fiancé Christopher Blevins, your steadfast faith in me across so many miles, encouraging phone calls, and cards has kept me going. Each visit home over the past two years always ended in tears, as I never wanted to say goodbye. Thank you for never doubting my ability to accomplish anything I set my mind to. More than anything else in my life right now, I am looking forward to getting married and finally sharing our lives together.

I am sincerely indebted to the Alderville First Nation and particularly Chief Nora Bothwell for the opportunity to study the skeletal remains in the Poole-Rose Ossuary. I would also like to thank the Pooles, who are the landowners of the excavation site, and Mr. Rose, the contractor who initiated the site's preservation by recognizing its significance to the historical record. Their cooperation has given Louisiana State

University and students a chance to explore the health of prehistoric peoples in an effort to learn more about those that lived before us.

Finally, I would like to thank my thesis committee, Ms. Mary H. Manhein for her words of encouragement, Dr. Becky Saunders for her enthusiasm and interest in my study, and to my advisor, Dr. Heather McKillop for her time, tedious revisions, and for the excavation of these skeletal remains for study. A very special thanks is in order for Dr. Miles Richardson, a professor and friend who so graciously gave his time and feedback during the writing of my thesis. I am also grateful to Dr. Jay Edwards and the Fred Kniffen Cultural Lab for providing me with the camera and work area for my photographs. Jason Ridley, thank you for helping me scan the slides into my document and offering your time whenever I needed it. I would also like to mention Dr. Susan Maki-Wallace of Baylor University. She is a role model, an example of a woman who aside from her family and professional career, devotes a tremendous amount of time to her students. I am indebted to her for everything she has done for me. To Michelle Lowery, Coordinator for the Office of Student Organizations & Campus Activities, thank you for your kind heart and listening ear. Your support and flexibility with my work schedule gave me the opportunity to focus so much of my time on my thesis. I have

enjoyed working for you! Last but not certainly not least, the friendship and respect of Mrs. Dana Sanders, Graduate Secretary for the Department of Geography and Anthropology, is perhaps more appreciated than she will ever realize.

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ABSTRACT

This study focuses on radii excavated from the Poole-Rose ossuary and analyzes the occurrence and patterning of degenerative joint disease (DJD) on the proximal and distal joint surfaces. The Poole-Rose ossuary, located in eastern Ontario, is dated to A.D. 1550 +/- 50. The Poole-Rose population, dating to the Late Woodland period, were agricultural in their subsistence activities. The disarticulated patterning of the skeletal remains suggests this site was associated with the "Feast of the Dead," a mass interment burial ceremony. This ceremony took place about every eight to twelve years.

Frequencies of lipping, porosity, and eburnation were reported in degree of severity for the proximal and distal joint surfaces. The results of this study are comprised of qualitative and quantitative analyses, including frequencies and co-occurrences of degenerative changes by joint surfaces. These results indicate that a combination of stress factors and possibly systemic factors are involved and responsible for the onset of DJD. Pitting alone appears to represent initial changes, while lipping and eburnation, most often accompanied by pitting, represent the more moderate and severe cases. Generally speaking, pitting is the most frequent characteristic

of DJD, proximal lipping is less frequent than distal lipping, and eburnation occurs in about 3.5% of all specimens.

The results of cross-tabulations indicate a statistically significant relationship between lipping and pitting on each joint surface, with the distal joint surface being affected more frequently by degenerative changes. Eburnation occurs in every case with lipping and pitting. Occurrence of degenerative changes suggests no statistically significant differences between the left and right sides. The Poole-Rose population was not subjected to severe levels of mechanical stress that might aggravate the onset of DJD or its initial changes.

CHAPTER 1

INTRODUCTION

The Poole-Rose ossuary, located in Eastern Ontario, was excavated in 1990 by a team of archaeologists led by Dr. Heather McKillop. Excavation began at the request of Chief Nora Bothwell during house construction on the Poole property, and the site became known as the Poole-Rose ossuary, named after the contractor and landowners. The ossuary appears to represent a demographically unbiased population containing juveniles, adults, males, and females (McKillop and Jackson, 1991). The site was radiocarbon dated to A.D. 1550 +/- 50, and is thought to be prehistoric in nature due to the lack of European artifacts characteristic of Iroquoian ossuaries. However, with such a date, it cannot be assigned to the category "prehistoric" with certainty (Pfeiffer, 1983). The patterning of the skeletal remains suggests that the Poole-Rose ossuary was a part of the "Feast of the Dead," a burial ceremony celebrated every eight to fifteen years (Tooker, 1964; Trigger, 1976).

The term "ossuary" refers to a burial pit (McKillop and Jackson, 1991) and can consist of multiple disarticulated or articulated remains. Typically, ossuaries are a form of secondary interment and are associated with the Feast of the Dead. In the case of the Huron Indians, this is the most

frequent and well-known burial practice (Knight and Melbye, 1983). During an ossuary burial, primary graves were dug up and the dead were placed in a large communal pit. Not included in this type of reburial were individuals who committed suicide, infants, and people who had died a violent death such as in war or by drowning (Tooker 1964). It is assumed that the deceased who were placed in the pit were those who were relatives of the people living at a particular place during a relatively fixed time period (Pfeiffer 1983). However, the disarticulation and commingling of the skeletal remains present difficulties to the archaeologist and anthropologist. Instead of specific individuals being studied, a particular population of humeri, radii, and other bones is analyzed instead, with the absence of measurable material to a large extent (Anderson, 1964). To date, several ossuaries have been excavated in eastern Canada and in the northeastern United States that show similar burial practices (Anderson, 1964; Churcher and Kenyon, 1960; Harris, 1949; Kidd, 1953; Knight and Melbye, 1983; McKillop and Jackson, 1991; Pfeiffer, 1983).

This study examines the presence and patterning of lesions associated with Degenerative Joint Disease (DJD), one of the most common pathologies of the human skeleton both now and in antiquity. This research is significant to both past and present ongoing research in the fields of physical anthropology,

archaeology, and paleopathology for several reasons. First, it is a prehistoric collection of skeletal material exceptionally well preserved. Second, existing federal and state legislation can be restrictive toward research on skeletal remains. The opportunity to study the Poole-Rose ossuary collection and the positive relationship between Alderville First Nation and Louisiana State University is a remarkable advantage. This study is theoretically significant because of its contribution to the body of current medical knowledge on DJD and serves as an excellent comparative study with past research, both in prehistoric and modern peoples. The large sample size of the material in the Poole-Rose ossuary as well as its exceptional preservation make this particular ossuary a reputable source for other comparative studies. Based on our knowledge of the Late Woodland people, it is interesting to look at what kinds of physical activities these people were engaging in during this specific period of time and the effects of physical impact on the joints and joint surfaces. One of the goals of this study is to examine DJD and its initial changes in the radius and speculate as to whether these individuals were or were not engaging in strenuous physical activities that may have impacted their skeletal remains. Another goal is to provide a glimpse into a specific period in time and provide a somewhat comprehensive demographic profile of ossuaries of this kind.

Literature Review

The Late Woodland people included Huron and Iroquois village farmers who, by the time of the arrival of Europeans in the seventeenth century, were at war with one another. Detailed historic accounts of the Huron provide information relevant to Late Woodland lifestyles (Tooker, 1964; Trigger, 1976). Whether or not the people interred in the Poole-Rose ossuary were Huron or Iroquois is unknown.

Intertribal relations between groups were both peaceful and antagonistic. Trade occurred between Indian groups as well as with the French and other Europeans, and often times trade relations between enemies such as the Huron and Iroquois resulted in violent actions. Fortifications and other lines of evidence indicate a high probability that warfare was present (Trigger, 1976). Basic Huron subsistence and their economy revolved around not only the seasons, but also activities such as hunting, gathering, fishing, and agriculture. Women were typically responsible for all of the agricultural work, while the men hunted, fished, and traded (Tooker, 1964). The seasonal cycle and activities would keep individuals away from their village most of the year, and both women and men would return to the village from their duties around December (Tooker, 1964).

The "Feast of the Dead," ceremony functioned as the most important of all ceremonies. The feast lasted approximately

eight to ten with the majority of time spent on preparations of individual relatives or friends who were to be buried in the communal ceremony. Gifts were presented in honor of the dead signifying a common tribute to and affection for the deceased; these acts of gift-giving functioned to promote unity between individuals, families, and many Huron tribes (Trigger, 1976).

Kenneth Kidd's (1953) excavation of a Huron ossuary, thought to contain the people of the Ossossane village suggests this particular site was associated with the "Feast of the Dead" ceremony witnessed by the French Jesuit missionary, Jean de Brebeuf in 1636. The accounts provided by Jean de Brebeuf are perhaps the most elaborate first-hand account of the "Feast of the Dead" ceremony (Kidd, 1953). Even scaffold dimensions provided by Brebeuf correspond to those dimensions uncovered during excavations. Kidd's study attests to the anthropological difficulties incurred when attempting to study fragmented and disarticulated skeletal remains. However, his excavation differs from that of the Poole-Rose ossuary in the number of artifacts recovered such as beads and shell ornaments (Kidd, 1953).

Paleopathology

Paleopathology, or the study of pathological conditions in early or prehistoric peoples (Wells, 1964; Pfeiffer, 1985), offers both advantages and disadvantages in studying

degenerative joint disease. A general understanding and knowledge of paleopathology provides a background of not only biological processes of modern and prehistoric peoples, but also a model of cultural adaptations to such things as environment. Due to the role physical factors play in the etiology of DJD, activity levels, especially related to subsistence, are often used as an indicator of what prehistoric activities people were engaged in. One of the advantages of paleopathological studies is that the behavioral and environmental shifts of a group of people can be studied in a culture or group spanning several hundreds or even thousands of years (Ortner and Aufderheide, 1991). Studying changes in settlement patterns and subsistence strategies can lead to a more behavioral perspective on DJD. Also, observations of pathological conditions in prehistoric remains contribute to a general understanding of the health status of a group of people (Pfeiffer, 1985). One disadvantage of paleopathology is the lack of soft tissue; dry bone can often be misleading and lead to confusion between discerning the extent and types of trauma and disease.

The earliest evidence of degenerative joint disease is found in the fossil remains of dinosaurs, with various joints being affected (Wells, 1964). DJD has also been noted among Neandertal remains, especially the La Chapelle-aux-Saints specimen. Not only was the jaw affected by degenerative

changes, but the vertebral column was also extensively involved (Wells, 1964). Based on evidence of DJD affecting the jaw, it can be hypothesized that the Neandertals of this time period had a diet composed of tough foods such as roots and nuts.

Although more than likely related to trauma, remains of ancient Nubians have been recovered with compression injuries to their necks, due perhaps to the habitual stress of carrying pots of water on their heads (Wells, 1964). This is a significant contribution to the literature on DJD, as repeated trauma has been deemed responsible in many cases for the onset of DJD and its initial expression.

Joint function and Degenerative Joint Disease

Degenerative joint disease generally has been regarded as a "wear and tear" phenomenon, or simply as degeneration of articular cartilage and friction in joint articulation (Sokoloff, 1969). Radin's (1993) definition of DJD refers to mechanically caused joint failure simultaneous with the destruction of articular cartilage. In more general terms, it is used in reference to arthritic changes of the joints and joint surfaces. A medical definition of DJD is presented by Aufderheide and Rodriguez-Martin (1998) that states, "DJD is a noninflammatory chronic, progressive pathological condition characterized by the loss of joint cartilage and subsequent lesions resulting from direct interosseous contact within

diarthrodial joints." In the human body, the major joints usually affected most frequently and most severely are the knee, hip, elbow, and shoulder. Commonly, DJD is subclassified into two categories, primary or secondary. Primary (80%) refers to no other cause being evident in the expression of DJD. Secondary (20%) is when the joint is altered by some other disease or event (Aufderheide and Rodriguez-Martin, 1998).

DJD, is also referred to in the literature as osteoarthritis, hypertrophic arthritis, or degenerative arthropathy (Aufderheide and Rogriquez-Martin, 1998). The focus of numerous research projects, DJD continues to be characterized by an extremely diverse etiology, making it difficult for a consensus to be reached (Jurmain, 1977, 1978, 1980, 1990; Ortner, 1966; Radin, 1993; Sokoloff, 1969). Consequently, degenerative joint disease is classified as a non-specific disease, meaning it is not caused by one single disease causing agent or factor, but rather from a conglomeration of different factors.

A common misnomer is to relate DJD directly to old age. Although age is a predisposing factor, and older people are more likely to show more degeneration of joints and joint surfaces, sometimes the opposite is true. Juveniles have also been known to show severe degenerative pathology while older adults show no signs at all (Jurmain, 1977).

There are two main classes of stress acting upon joint surfaces that together make up the etiology of the disease. These include mechanical stress induced by particular functions extrinsic to the human body and systemic factors. Examples of mechanical stress include increased weight bearing and loading of the joints, trauma, and occupational as well as environmental stimuli. Systemic factors include heredity, nutrition, age, sex, hormones, and possible tissue regeneration (Sokoloff, 1969). Increased activity can spur the onset of DJD, but exactly which type and what joints are affected is impossible to determine through skeletal remains alone (Jurmain, 1999). In addition, degeneration due to age can be problematic due to the fact that there are differences in general life expectancies between contemporary peoples and those that lived hundreds and thousands of years ago.

The expression of DJD is not only diverse, but can be obscure in its pathology. The principal features that characterize DJD include loss of cartilage, bone remodeling or the formation of new bone typically seen at the margins of a joint, classified as either lipping or osteophyte formation, porosity of the bone surface, subchondral cysts, and eburnation (Aufderheide and Rodriguez-Martin, 1998). Porosity, or pitting is another characteristic of DJD, but is not a good indicator alone due to the fact that even healthy bone can show signs of

minimal pitting. Porosity can be difficult to distinguish due to the fact that the type of hole produced can be due to thinning of the bone surface as seen in degenerative joint disease, or vascular invasion, which occurs in healthy bone (Jurmain, 1999). Rothschild (1997) also points out that porosity might result from processes separate than those that produce degenerative changes. Therefore, evaluation of porosity may have little to contribute to understanding DJD, and does not appear to be very indicative of severe DJD (Jurmain, 1999). This is relevant to the current study, as a majority of the specimens showed at least some minimal pre-mortem pitting; therefore, only moderate and severe cases are being classified as being affected by DJD. Eburnation is the smooth and polished appearance of bone caused by contact of bones directly against one another. This occurs when the articular cartilage is no longer present, or severely degenerated. Eburnation occasionally can be seen in its more severe state accompanied by the production of grooves or ridges.

Basic joint stability and function are ensured by factors such as ligaments, muscles, and synovial fluid in and around joints, allowing different joints to produce different ranges of motion. The stability of the ankle is worthy of note because it resists DJD, probably due to the extensive ligament network in the ankle; DJD is not as commonly reported in the ankle as in

other joints (Sokoloff, 1969). In order to function properly, joints require at least minimal activity (Jurmain, 1999). Synovial fluid is the protective lubricant that covers the joint surface and cartilage, and acts to reduce friction between two bones at a joint (Radin and Wright, 1993). Most of the joints described in the literature as being most affected by DJD are diarthrodial, or where articular surfaces glide freely across each other permitting a wide range of motion. The articulation of the radius and humerus is an example of diarthroses, as well as the shoulder and hip joints (Wright and Radin, 1993).

The radius itself is located in the forearm and articulates with the humerus, ulna, and scaphoid and semilunar bones of the hand (Gray 1974). Within the radius in particular, there are two types of movement that can take place. Rotation of the joint at the radiohumeral aspect includes pronation and supination. The gliding motion of flexion and extension combined with rotational forces within the radiohumeral articulation ultimately cause more rubbing in this part of the elbow (Jurmain, 1978). Essentially, joints function as bearings in a mechanical system, and factors such as external loading, repeated impacts, and even body weight can contribute to the onset of DJD. Large weight bearing joints in the lower extremities are usually affected the earliest by DJD (Aufderheide and Rodriguez-Martin, 1998).

Jurmain (1999) points out that "in addition to type of activity, duration, amplitude, and sense (torsion vs. compression) are all significant. They vary independently and produce variable effects." Traumatic injury and infection can accelerate the onset and expression of DJD. Diseases such as periostitis and osteomyelitis are two examples. Periostitis is inflammation of the membrane covering the bone (periosteum) and is usually caused by infection or trauma to the skin. Osteomyelitis is inflammation of the bone and bone marrow (Aufderheide and Rodriguez-Martin, 1998).

Despite the fact that degenerative joint disease is a common pathological condition, no simple etiological explanation exists. Distribution and patterning of DJD in skeletal remains thus takes on a multi-factorial model (Jurmain, 1977). Future studies on DJD might look at isolating specific activities and their possible influence on DJD, perhaps in a more modern clinical setting, suggested by the literature on sports medicine and athletes.

One of the greatest challenges in research on DJD, both on an individual research level as well as the collaborative effort among scholars everywhere, is the problem of standardization. Buikstra and Ubelaker (1994) have recently published certain criteria suggested for standard data collection and measurements, but not all researchers follow these guidelines.

What one must remember is that individual interpretation takes the forefront when studying DJD. Interpreting whether or not porosity is present (incidence) and to what extent (prevalence), can differ from one osteologist to the next. These different methods of scoring and interpretation are what lead to inconsistencies (Jurmain, 1999). However, complications can sometimes be avoided by simply choosing a single method of evaluation or seriation, and then being consistent with whatever method is chosen. In methodology, the consensus has been that simpler is better, and generalizations as to which joints show the greatest or least amount of incidence is acceptable research (Jurmain, 1999). Contemporary and clinical studies are being conducted to help learn more about DJD, especially its etiology, and more collaboration is still needed.

The goal of this research is to provide another comparative work in Ontario-Iroquois paleopathology, using other studies not only in published reports outside of the Poole-Rose ossuary, but within this sample of individuals as well. Hopefully, a comparison can hopefully be made both geographically and temporally with other long bones, especially those that articulate with the radius. Though it is difficult to use comparative studies due to their variability in observation and classification of variables (Ortner and Aufderheide, 1991),

there is much to be learned from similar studies that can contribute to the understanding of degenerative joint disease.

Degenerative Joint Disease Among Late Woodland Ossuary Populations

Numerous studies have been conducted in both clinical as well as anthropological and archaeological contexts to better understand degenerative joint disease (DJD) and its etiology, as well as gather information about the activities and life ways of past populations. Although its exact etiology is elusive, DJD is considered to be one of the most common diseases affecting joints and joint surfaces, occurring not specifically due to old age as the term degenerative may indicate (Anderson, 1964; Aufderheide and Rodriguez-Martin, 1998; Jurmain, 1999). Wells (1964) suggests that such factors as cumulative strain over many years and repeated episodes of minor stress are important factors in the onset of DJD. In addition, specific activities associated with the every day life of a group of people can aid in determining what joints will be affected or where one would expect to find initial and advanced stages of degenerative changes.

Harris (1949) presented evidence of disease in the remains of the ossuary of Cahiague as being representative of Huron Indians of this time period. DJD, or osteoarthritis as referred to by Harris, was observed in the spine with other joints being

rarely affected. The most interesting finding was that of squatting facets on the tibia and talus, which were present in almost 50% of all tibiae. This find supports the hypothesis that repeated, functionally-induced stress on joints, especially related to specific activities, can over time cause degenerative changes characteristic of DJD. Even today, tennis players are more likely than soccer players to develop tennis elbow, and typists are more likely than gymnasts to develop carpal tunnel syndrome. Certain repetitive activities can be responsible for dictating what joints or articular surfaces are affected. In tennis players it is the shoulder, elbow, and wrist that are more likely to be affected. In downhill skiers the lower limbs are more likely to suffer an earlier onset of degenerative changes.

Anderson (1964) analyzed DJD in the 36,000 bones and fragmented specimens of the Fairty ossuary dated to about A.D. 1400, excavated near Toronto, Ontario. Based on humeri, the minimum number of individuals (MNI) was estimated to be about 512 (Anderson, 1964). General percentages of DJD were given for several long bones, including the humerus, radius, and ulna, which are relevant to this study of DJD in the radii of the Poole-Rose ossuary. Less than 10% of humeral heads were affected, while about 5% of the distal part of the humeri showed some form of degenerative change. Typically, this DJD was a

round, discrete area of erosion on the capitulum with some marginal lipping. However, the incidence was more extensive in the distal part of the humeri. DJD was present in about 9% of proximal and distal articular surfaces of all radii, and in about 19% of proximal ends and about 15% of distal ends of all ulnae. The exact location and severity of DJD was not recorded.

From his study on the Fairty ossuary, Anderson (1964) suggested some generalizations that characterize DJD, which he proposed can begin to manifest itself early in adult life. These characterizations were followed by subsequent researchers and provide a model of the expression of DJD and its tendencies. The most noticeable characteristic is the distinctive patterning of the expression of DJD for each particular joint surface. For instance, the typical expression is usually a combination of pitting of the bone underlying cartilage, lipping of the articular surface, formation of new bone (osteophytes), and the presence of eburnation. Also, there can be variation in the incidence at different joints, especially in two bones that articulate at the same joint surface. In the Fairty ossuary, there was a minimal difference in incidence between left and right specimens.

Bridges (1991) analyzed and compared degenerative joint disease in two populations, Archaic hunter-gatherers and Mississippian agriculturalists from northwestern Alabama. The

purpose of the study was to see what differences, if any, existed between the two groups, and what the results might reveal about their activities. Scoring was performed separately for each joint surface based on severity of lipping, porosity, and eburnation. Bridges found that the frequency of DJD was low at the hip, but significantly higher in the shoulder, elbow, and knee for both left and right sides. The hunter-gatherer group showed more cases with moderate to severe DJD than the agriculturalists, although the overall prevalence of DJD in Bridges' (1991) study was similar in hunter-gatherers and agriculturalists, suggesting similar activities and activity levels.

However, there is a potential age bias as the hunter-gatherer sample had older individuals represented. DJD was generally mild in its expression and not as frequent in the Archaic peoples of the Great Lakes (Pfeiffer, 1985), or in CA-ALA-329, a central California prehistoric population studied by Jurmain (1990). However, the variability in DJD expression makes it difficult to assess a direct correlation between the introduction of agriculture and DJD.

Other Studies

Jurmain (1978) studied degenerative joint disease of the elbow in his study on modern and prehistoric samples of black and white Americans, twelfth century Indians, and Alaskan

Eskimos. DJD was studied on the distal humerus, and the proximal ulna and radius. His research is interesting because in addition to describing DJD, he notes that the joints of Eskimos are more frequently and severely involved. Jurmain proposes that higher levels of functional stress may be responsible for increased prevalence in Eskimos, but more data is needed on specific cultural behaviors in order to correlate DJD with Eskimo lifestyle. Since rotation and gliding articulatory movements occur conjointly at the radiohumeral joint, there is increased friction in this part of the elbow; this friction may also correlate with the nature, degree of involvement, and location of DJD.

Comparative studies on individuals from a similar time period and geographical area, especially those who share similar cultural behaviors, can give tremendous insight into DJD and its expression. Another considerable research model would be to utilize modern medicine, and employ contemporary studies to isolate specific activities and joints affected by symptoms of DJD. The major disadvantage to this type of study is that x-rays can only provide so much information, and true characteristics of DJD cannot be studied unless conducted postmortem. An example would be to study tennis players and "tennis elbow," or baseball pitchers and DJD of the shoulder joint. The isolation of these specific activities gives the

researcher somewhere to begin, and can be helpful in understanding the progression of DJD.

Jurmain's (1999) classification system of lipping, porosity, and eburnation was based on the degree of severity of degenerative involvement. The categories were, none/slight, moderate, and severe (Jurmain, 1977, 1978, 1999). The Eskimo collection was most affected by DJD, especially at the elbow. Blacks had a tendency to be more affected than whites, and the Pecos collection was the least affected by DJD of the populations analyzed. In another similar study of a central California prehistoric population also studied by Jurmain, he found the highest involvement of DJD in the hands and feet. However, this collection showed less frequent involvement of DJD than the Eskimo collection. Jurmain also suggested specific activities that could contribute to the high frequency of DJD in the Eskimo collection. In terms of sex, he also confidently suggested that systemic factors were also acting in females who were perhaps not engaged in severe mechanical stress.

Rothschild and Woods (1992) have supplemented the research on DJD and prehistoric human populations with that of evaluating DJD in artificially restrained versus free-ranging Old World primates. DJD was more common in artificially restrained specimens than in free-ranging specimens, where DJD was present in the hip and elbow. In free ranging primates, DJD was more

common in the knee. Skeletal distribution of degenerative changes differed significantly between the two populations. In the artificially restrained group, 57% showed DJD of the elbow, and in the free-ranging group, 80% showed DJD of the knee. The conclusion that Rothschild and Woods came to in this particular study was that the patterning of DJD in Old World primates was comparable to that noted in humans (Rothschild and Woods, 1992), where DJD often depends on what type of functional stress is being applied to what part of the body. For example, the sample with free range capabilities developed DJD of the knee before the artificially restrained sample.

This thesis research focuses on the radius to evaluate the presence and incidence of common degenerative changes in the joints, leading to degenerative joint disease, or DJD. Articular joint surfaces of the radius were analyzed and seriated according to degree of degeneration based on porosity, lipping, and eburnation. The presence and patterning of lesions were observed and compared with other research on the Poole-Rose ossuary, in addition to other ossuary and clinical analyses. An interesting point of discussion will be that of addressing DJD and the humerus, especially due to its direct articulation with the radius at the radiohumeral joint. Although research on the ulna in the Poole-Rose ossuary is currently not complete, speculations as to what one might expect to find based on the

humerus and radius will hopefully stimulate even more scholarly literature on DJD.

CHAPTER 2

MATERIALS AND METHODS

The Poole-Rose skeletal material was sorted, washed, and catalogued by professors and students at Louisiana State University, and assigned catalog numbers based on excavation unit, level, and bone number. The radii which included whole bones, proximal ends, distal ends, and shafts were sorted according to left, right, and undetermined sides. Attempts were made to match fracture lines and reconstruct bones. Adult bones were analyzed in this study. Age and sex were not determined.

Adult bone measurements were taken on complete bones using an osteometric board. Maximum length was measured from the radial head to the tip of the styloid process in millimeters (Bass, 1995). Using a small, digital sliding caliper, radial head diameter was also measured in millimeters. Comparisons were made with lengths of radii from other Late Woodland ossuaries.

The articular joint surfaces of the radius were analyzed for DJD. The head of the radius, which articulates with the humerus; the distal facet, which articulates with the scaphoid and semi-lunar bones of the hand; and the ulnar notch, which articulates with the ulna, were each evaluated separately for three types of bone lesions suggesting degenerative changes. The radii were seriated according to degree of degeneration for

porosity, lipping, and eburnation. To aid in seriating such a large sample, each bone was assigned a degree, or category according to presence of DJD: Absent or not present, present/minimal, and moderate/severe. Based on Buikstra's and Ubelaker's recording standards for data collection (1994), the degree of porosity and lipping respectively was assigned as such:

- Minimal= pinpoint pitting or individual pits numbering very few
- Moderate= Several groups of coalesced pitting, occurring in more than one location, and often on both the joint surface and marginal areas
- Severe= Presence of both pinpoint and coalesced pitting on over 50% of the joint surface.

For the statistical analysis, specimens were grouped into the categories of absent, present/minimal, and moderate/severe. Due to the small number of specimens in the last two categories, however, specimens with moderate and severe expression of DJD were combined into one group.

Porosity or pitting of the joint surface is often applied inconsistently and is poorly defined. Distinguishing between premortem and postmortem pitting is relatively simple with the aid of a microscope, but the classification of what causes the

pitting can be difficult to assess in skeletal remains.

Porosity may develop due to thinning of the articular plate and vascular invasion of calcified cartilage, and may not be related at all to DJD (Jurmain, 1999).

A Nikon stereoscopic microscope was used to identify premortem from postmortem pitting on the joint surfaces. Premortem pitting was identified as such by the rounded and smooth edged appearance of the pits, obviously not due to postmortem handling or disintegration. Lipping and eburnation were identified by the naked eye, with extent of eburnation being confirmed by use of a microscope. In addition to the identification of these three characteristics, I looked for large centralized pits with additional bone buildup in the center of the joint capsule.

Prevalence as well as the patterning of the lesions was observed. Colored dots were placed on the radii to mark the location of pitting, lipping, and eburnation on each joint surface. The data were entered into Microsoft Excel 2000 spreadsheet and SPSS 10.0 for Windows. SPSS was used for statistical analysis. Two-way frequency tables were created to compare presence and degree of severity of observations by joint surface, side, and in relation to other DJD observations. Chi-square tests were used to determine which frequencies were

statistically significant. The significance level was set at .05.

CHAPTER 3

RESULTS AND DISCUSSION

Minimum Number of Individuals

The total number of specimens in my collection for study is 881, including 83 whole radii, 293 proximal ends, 240 distal ends, and 265 radial shafts. There are ten complete juvenile bones, 47 proximal ends, 43 distal ends, and 22 radial shafts. Fifteen juvenile radial epiphyses are also present, for a total of 139 juvenile specimens. Juvenile radial bones were classified as such and separated according to epiphyseal fusion of the head and distal aspects of the radius (Buikstra and Ubelaker, 1994). Typically, the proximal epiphysis fuses to the shaft around age seventeen or eighteen. The distal epiphysis fuses to the shaft around age twenty (Gray, 1974).

Determination of the minimum number of individuals (MNI) was based on four aspects of the radius including the presence or absence of the radial head, nutrient foramen, distal facet, and ulnar notch. At least 51% of each feature was required to be present in order to be included as a distinct individual. Totals were figured for both left and right sides based on these four features. The most represented feature was the nutrient foramen of the left radius, and from this the MNI was determined to be 205 (Table 3.1). Due to the small number of juvenile whole

bones and the number of fragmentary specimens, distinguishable MNI features were difficult to determine. Therefore, juvenile MNI is not being reported.

Table 3.1. Minimum number of individuals (MNI) based on features present on the radius

	LEFT	RIGHT
HEAD	159	153
NUTRIENT FORAMEN	205	184
DISTAL FACET	171	177
ULNAR (MEDIAL) NOTCH	133	153

The MNI of 205 calculated for this sample on the radius can be compared with the MNI derived by other researchers for other skeletal elements in the Poole-Rose ossuary (Table 3.2). Differential preservation and the fragmentary nature of the remains help to explain why there are different numbers for MNI within the Poole-Rose ossuary.

Other ossuary studies such as Tabor Hill yield similar results in terms of MNI and even stature measurements. In the Fairty sample, MNI was based on the humerus and was calculated to be 512. In the Tabor Hill ossuaries, the MNI was significantly smaller and more comparable to the Poole-Rose population at 213.

Table 3.2. Minimum number of adult individuals (MNI) for the Poole-Rose ossuary

<i>SKELETAL ELEMENT</i>	<i>MNI, reference</i>
Second cervical vertebra	172, Dunne, 1999
Left deltoid tuberosity of the humerus	249, Lundin, 2000
Nutrient foramen of right tibia	193, Bordelon, 1997
Hip	250, Tague et al., 1998
Right third metacarpal	145, Kelly, 2001

Measurements of Adult and Juvenile Radii

The maximum length of the adult bones is similar to that reported in other Late Woodland ossuary studies (Churcher and Kenyon, 1960), which suggests that individuals of this time period were of similar stature. The average length for the 74 whole bones in this sample is 255 mm. The average radial head diameter for 197 specimens with at least 51% of the head present is 22 mm. The mean length of the adult radii in the Poole-Rose sample is exactly the same as that of the Tabor Hill ossuaries (255 mm), given an average between males and females in the latter (Churcher and Kenyon, 1960).

Juvenile maximum bone lengths are given for the right and left sides. Only five whole bones are present for each side, and the average length is 127.4 mm for the left side and 84.6 mm for the right side. Perhaps this difference in average length is due to the small sample size and different ages of the individuals.

Observations and Quantitative Analysis of Porosity, Lipping, and Eburnation on Adult Radii for the Poole-Rose Ossuary

The results of this study are presented in terms of frequencies of lipping, porosity, and eburnation by joint surface, in order to evaluate trends in the presence of degenerative joint disease.

Table 3.3. Number and percentage of observations

<u>Observations</u>	<u>Present/Minimal</u>	<u>Moderate/Severe</u>
Proximal Pitting	185/371 or 49.9%	72/371 or 19.4%
Distal Pitting	239/314 or 76.1%	64/314 or 20.4%
Proximal Lipping	46/370 or 12.4%	12/370 or 3.2 %
Distal Lipping	137/309 or 44.3%	28/309 or 9.1%
Proximal Eburnation		9/371 or 2.4%
Distal Eburnation		15/314 or 4.8%

Side and patterning of DJD, as well as a chi-square analysis, are provided to supplement and support the qualitative analysis. The small values associated with moderate/severe DJD complicate the cross-tabulations and chi-square analysis. Some statisticians place a requirement of minimal values per cell (5) for a chi-square test, and to an extent, the small expected values in the moderate/severe category may affect the validity

of the test. When the degrees of freedom are greater than one, as in this analysis, typically the expected frequencies should be at least five (Kirk, 1990). However, the results are still reported and any error is assumed to be relatively minor. The sample for the study of degenerative joint disease includes only adult specimens.

Pitting

In terms of the overall presence and absence of pitting in this study, pitting usually appeared independently on its own and accompanied or preceded lipping in advanced stages of DJD. Slight pitting is often not categorized as clinical degenerative joint disease due to the difficulty in distinguishing between pitting due to vascularization, which occurs in healthy bone, and pitting due to thinning of the bone surface as seen in degenerative joint disease (Jurmain, 1999). Buikstra and Ubelaker (1994) have noted that natural variation in bone can produce pitting that is not directly related to degenerative joint disease (Figures 3.3 and 3.4). In the Poole-Rose sample, about 62% of the specimens analyzed for pitting on both proximal and distal joint surfaces showed at least some degree of minimal pitting, while about 20% showed moderate to severe pitting. Pitting appears to be the most prevalent characteristic of DJD in the radii, followed by lipping and eburnation.

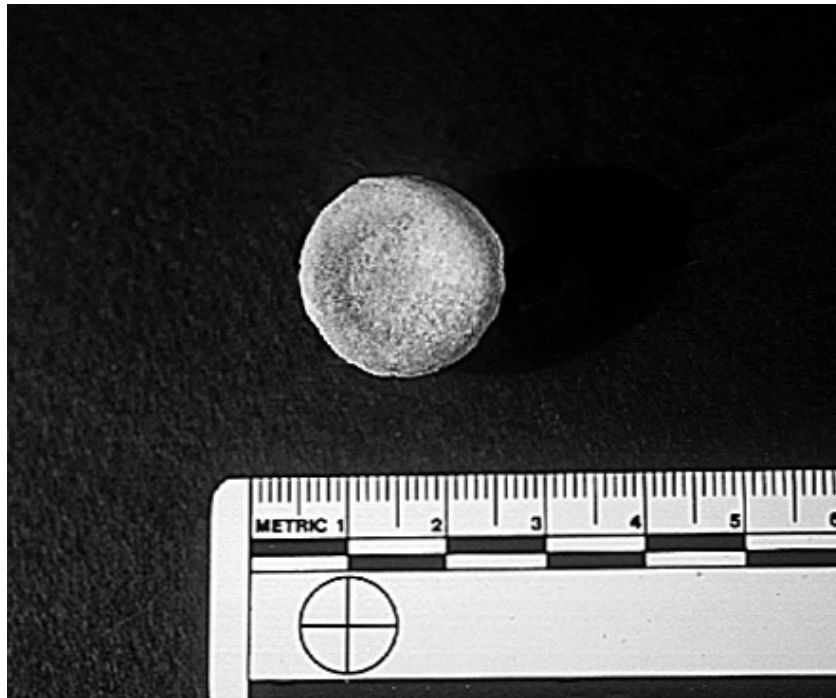


Figure 3.1. Proximal radius with no lipping, pitting, and eburnation. Specimen number 3-22-205/7-22-526.



Figure 3.2. Distal radius with no lipping, pitting, and eburnation. Specimen number 3-22-205/7-22-526.

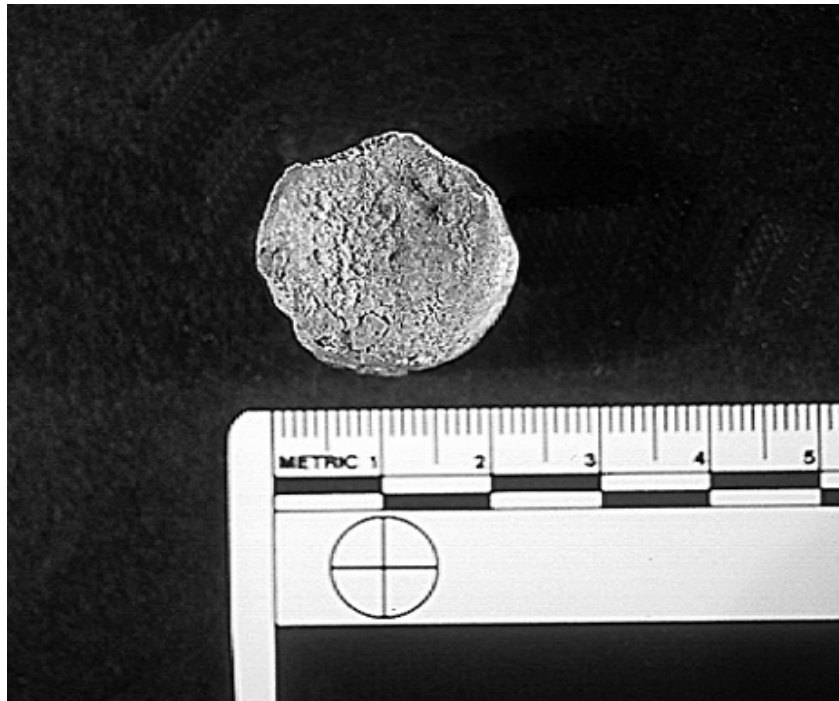


Figure 3.3. Moderate/Severe pitting of the radial head. Specimen number 3-24-2901.



Figure 3.4. Moderate/Severe pitting of the distal facet. Specimen number 2-24-3069/ 2-24-357.

Lipping

Lipping is less frequent, with distal lipping more prominent than proximal lipping. In the Poole-Rose sample, about 27% showed minimal lipping, while about 6% showed moderate to severe lipping. Lipping was most frequent at the joint margins, but some lipping was also present on the joint surface where bone remodeling was observed. See tables 3.4-3.7 for occurrences of lipping and pitting by joint surface.

Table 3.4. Proximal lipping and proximal pitting

		Proximal Pitting			
		Absent	Present/ Minimal	Moderate/ Severe	Total
Proximal Lipping	Absent	111	154	46	311
	Present/ Minimal	2	30	14	46
	Moderate/ Severe		1	11	12
Total		113	185	71	369

$\chi^2 = 61.9$, $p \leq .001$ (Significant)

Table 3.5. Proximal lipping and distal pitting

		Distal Pitting			
		Absent	Present/ Minimal	Moderate/ Severe	Total
Proximal Lipping	Absent	5	57	10	72
	Present/ Minimal		10	1	11
	Moderate/ Severe		1	1	2
	Total	5	68	12	85

$\chi^2 = 3.3, p = .506$

Table 3.6. Distal lipping and proximal pitting

		Proximal Pitting			
		Absent	Present/ Minimal	Moderate/ Severe	Total
Distal Lipping	Absent	15	27	7	49
	Present/ Minimal	5	19	4	28
	Moderate/ Severe	1	2	2	5
	Total	21	48	13	82

$\chi^2 = 4.0, p = .411$

Table 3.7. Distal lipping and distal pitting

		Distal Pitting			
		Absent	Present/ Minimal	Moderate/ Severe	Total
Distal Lipping	Absent	7	127	9	143
	Present/ Minimal	4	102	31	137
	Moderate/ Severe		7	21	28
	Total	11	236	61	308

$\chi^2 = 71.2, p \leq .001$ (Significant)

Based on prior knowledge, one would expect that lipping and pitting are related to one another, especially since the frequencies here suggests pitting precedes lipping. If this is the case, then a chi-square analysis should be in agreement with the qualitative hypothesis that there is a significant relationship between pitting and lipping occurring on each joint surface. The results illustrate that there is a significant relationship for each individual surface. There is no significant relationship evident, however, when looking at lipping on one joint surface and pitting on the other or vice versa (Figures 3.5 and 3.6).

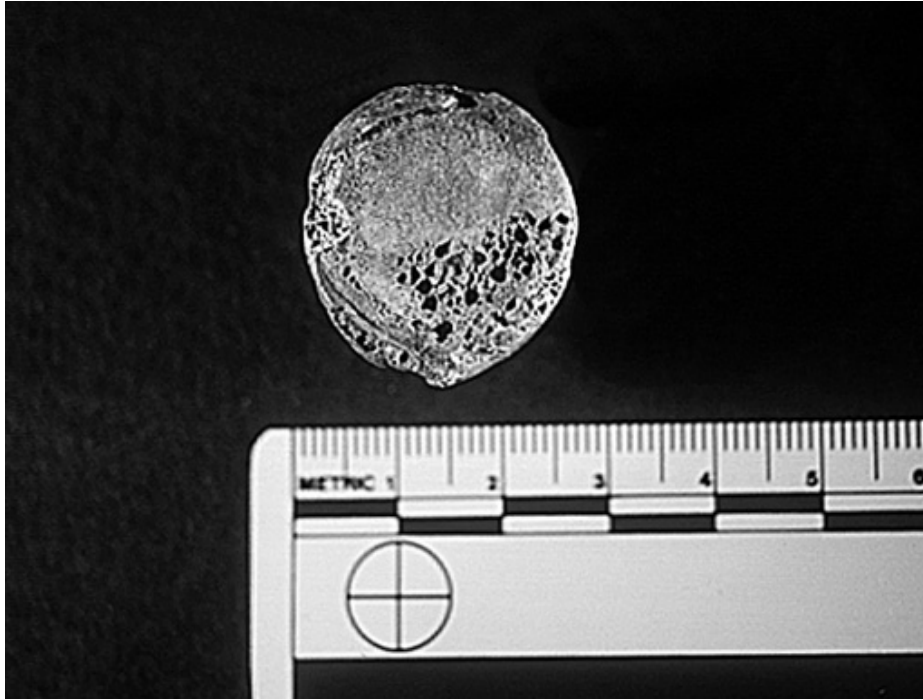


Figure 3.5. Moderate/Severe lipping of the radial head, accompanied by pitting. Specimen number 9-24-7.



Figure 3.6. Moderate/Severe lipping of the distal facet, accompanied by pitting. Specimen number 6-29-2265.

Eburnation

Eburnation is seen in about 3.5% of all cases of the radii analyzed, and is therefore assumed to indicate the most severe cases of DJD present in the Poole-Rose ossuary. If DJD moves in a progression of stages, then it would be reasonable to assume eburnation would be associated with lipping and pitting. Since the complete erosion of articular cartilage away from the joint surface or capsule causes eburnation, in these results it is almost always accompanied by another characteristic of DJD, usually both lipping and pitting. See tables 3.8-3.11 for occurrences of lipping and eburnation by joint surface.

Table 3.8. Proximal lipping and proximal eburnation

		Proximal Eburnation			Total
		Absent	Present- Joint Surface	Present- Perimeter	
Proximal Lipping	Absent	309	2		311
	Present/ Minimal	45		1	46
	Moderate/ Severe	6	5	1	12
	Total	360	7	2	369

$\chi^2 = 123.8, p \leq .001$ (Significant)

Table 3.9. Proximal lipping and distal eburnation

		Distal Eburnation			
		Absent	Present-Joint Surface	Present-Ulnar Facet	Total
Proximal Lipping	Absent	69	3		72
	Present/Minimal	11			11
	Moderate/Severe	1		1	2
	Total	81	3	1	85

$\chi^2 = 42.5, p \leq .001$ (Significant)

Table 3.10. Distal lipping and proximal eburnation

		Proximal Eburnation		
		Absent	Present-Joint Surface	Total
Distal Lipping	Absent	49		49
	Present/Minimal	27	1	28
	Moderate/Severe	4	1	5
	Total	80	2	82

$\chi^2 = 7.9, p \leq .025$ (Significant)

Table 3.11. Distal lipping and distal eburnation

		Distal Eburnation			
		Absent	Present-Joint Surface	Present-Ulnar Facet	Total
Distal Lipping	Absent	143			143
	Present/Minimal	132	3	2	137
	Moderate/Severe	18	8	2	28
	Total	293	11	4	308

$\chi^2 = 67.3, p \leq .001$ (Significant)

The occurrence of lipping and eburnation by joint surface yields interesting results; they differ in one major aspect as compared with the results between lipping and pitting by joint surface. Whereas lipping and pitting co-occur with one another only in the same location (proximal or distal surface), lipping and eburnation correlated regardless of location. Just as pitting and lipping are often seen together, lipping and eburnation tend to occur together (Figures 3.7 and 3.8).

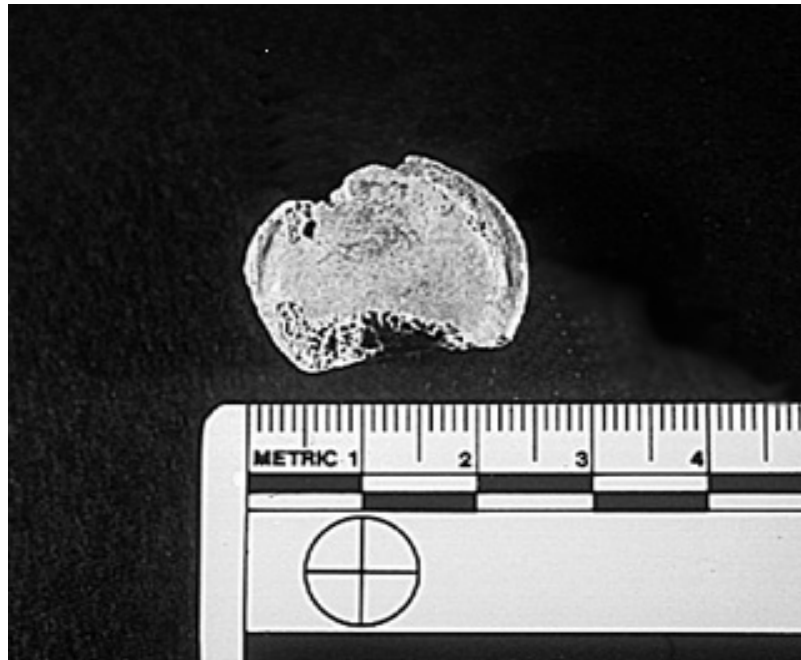


Figure 3.7. Eburnation of the joint surface on the radial head. Specimen number 9-24-397.

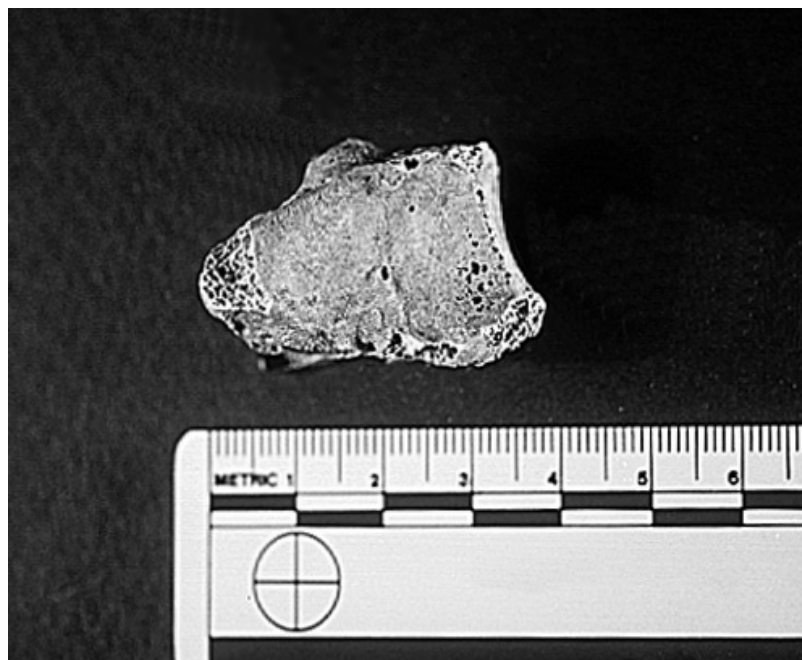


Figure 3.8. Eburnation of the joint surface on the distal facet. Specimen number 6-24-401.

Finally, pitting and eburnation were analyzed to see if there was a significant relationship between the presence of the two on the proximal and distal joint surfaces. Based on the previous statistical analyses and general observations, one would expect to find a relationship between the two. The results of this analysis were similar to that of lipping and pitting, where the two variables were significantly related, but only on the same joint surface. Pitting and eburnation on the proximal surface have a statistically significant co-occurrence ($p < .05$). Pitting on the proximal aspect and eburnation on the distal are not significantly correlated. See tables 3.12-3.15 for occurrences of pitting and eburnation by joint surface.

Table 3.12. Proximal pitting and proximal eburnation

		Proximal Eburnation			
		Absent	Present-Joint Surface	Present-Perimeter	Total
Proximal Pitting	Absent	114			114
	Present/Minimal	185			185
	Moderate/Severe	63	7	2	72
	Total	362	7	2	371

$\chi^2 = 38.3$, $p \leq .001$ (Significant)

Table 3.13. Proximal pitting and distal eburnation

		Distal Eburnation			
		Absent	Present-Joint Surface	Present-Ulnar Facet	Total
Proximal Pitting	Absent	22	1		23
	Present/Minimal	47	1		48
	Moderate/Severe	12	1	1	14
	Total	81	3	1	85

$\chi^2 = 6.1, p = .19$

Table 3.14. Distal pitting and proximal eburnation

		Proximal Eburnation		
		Absent	Present-Joint Surface	Total
Distal Pitting	Absent	5		5
	Present/Minimal	67	1	68
	Moderate/Severe	11	1	12
	Total	83	2	85

$\chi^2 = 2.2, p = .33$

Table 3.15. Distal pitting and distal eburnation

		Distal Eburnation			
		Absent	Present-Joint Surface	Present-Ulnar Facet	Total
Distal Pitting	Absent	11			11
	Present/Minimal	237	1	1	239
	Moderate/Severe	51	10	3	64
	Total	299	11	4	314

$\chi^2 = 43.1, p \leq .001$ (Significant)

Side

The results from the Poole-Rose population show no significant statistical relationship between side and any of the variables, with the exception of side and pitting on the proximal radius. The left side of the proximal joint is affected slightly more than the right side in the category for minimal pitting only. See tables 3.16-3.21 for an evaluation of side by joint surface.

Table 3.16. Side and pitting on the proximal radius

	Absent	Present/Minimal	Moderate/Severe	Total
Left	58	59	26	143
Right	29	79	23	131
Total	114	185	72	371

$\chi^2 = 14.2, p = .007$ (Significant)

Table 3.17. Side and pitting on the distal radius

	Absent	Present/ Minimal	Moderate/ Severe	Total
Left	4	111	38	153
Right	7	128	25	160
Total	11	239	63	313

$\chi^2 = 4.6, p = .103$

Table 3.18. Side and lipping on the proximal radius

	Absent	Present/ Minimal	Moderate/ Severe	Total
Left	126	12	4	142
Right	107	20	5	132
Total	233	32	9	274

$\chi^2 = 3.7, p = .448$

Table 3.19. Side and lipping on the distal radius

	Absent	Present/ Minimal	Moderate/ Severe	Total
Left	66	70	15	151
Right	78	66	13	157
Total	144	136	28	308

$\chi^2 = 1.1, p = .564$

Table 3.20. Side and eburnation on the proximal radius

	Absent	Present- Joint Surface	Present- Perimeter	Total
Left	139	4		143
Right	128	2	1	131
Total	267	6	1	274

$\chi^2 = 2.4, p = .658$

Table 3.21. Side and eburnation on the distal radius

	Absent	Present- Joint Surface	Present- Ulnar Notch	Total
Left	146	5	2	153
Right	152	6	2	160
Total	298	11	4	313

$\chi^2 = .06, p = .973$

Discussion

The findings of this study reveal intriguing patterns of degenerative joint disease that encourage discussion and comparison not only with the medical literature, but similar skeletal material as well. The study of degenerative joint disease of the radius in the Poole-Rose ossuary population makes a significant contribution to the etiology of DJD and confirms its diverse and elusive nature. The ultimate goal in interpreting the results is to make a general statement concerning degenerative joint disease in this population of people, and to see how well it fits with other studies on DJD. Due to the fact that DJD occurs mainly at joint surfaces where bones articulate with other bones, it is relevant to this research to look at articulation of the radio-humeral joint, and to see if there is a significant relationship between the manifestation of degeneration on each bone independently. In

the Poole-Rose ossuary sample, DJD has been studied on the humerus, while the research on the ulna has yet to be completed.

What does this research tell us about the patterning of degenerative joint disease? First, it suggests that degenerative changes on the radius, if they are lipping or eburnation, occur in the presence of at least one other characteristic. Due to this factor, it may be reasonable to suggest that the classification of DJD be labeled as indicative of DJD according to the degree of lipping and eburnation, the more severe characteristics of DJD. Also note that these two characteristics occur in a relatively small percentage of the Poole-Rose population. Second, the incidence of DJD and its co-occurrence with other characteristics helps to shed light on the progression of stages and severity of DJD in the radius. In future research, a useful technique would be to study DJD on entire skeletons in one particular population to better understand the lifestyle of that particular group of people. Comparing those results with other ossuary studies as well as with contemporary medical research might yield more useful information on the elusive etiology of the disease and specific activities associated with DJD.

The results of this study and the overall comparable frequencies of degenerative changes on the radius are consistent with the hypothesis that the Poole-Rose population was exposed

to functional stress of their joints. The frequencies of involvement on the proximal and distal surfaces, in addition to the relationships between characteristics of DJD variables both qualitatively and quantitatively, are as expected with regard to a functional stress hypothesis. Overall, about 20% of all specimens analyzed showed moderate/severe pitting, 6% showed moderate/severe lipping, and 3.5% showed moderate/severe eburnation. The results also compare well with studies on other ossuary skeletal remains and in terms of medical literature on DJD.

Ortner (1966) looked at DJD on the distal joint surface of the humerus. In an attempt to describe and classify degenerative changes of the elbow, Ortner found that DJD on the humeral joint surface was also reflected in the radial and ulnar joint surfaces. Ortner found that the greatest area of contact and degeneration occurred at the center of the radial head due to the concavity of the radial head and the rounded shape of the capitulum. Any mechanical stress that was applied to this particular joint surface would therefore be concentrated, and appear as a small rounded area of degeneration.

Ortner focused on the same characteristics of DJD as that examined in this study on the proximal and distal aspects of the radius. Although he discussed age and metabolism as having effects on the onset and initial degenerative changes indicative

of DJD, a functional or stress related hypothesis was suggested for the more severe changes. In general, the overall conclusion of Ortner's research on the humerus coincides well with the radius in this study. Eburnation rarely occurred without porosity, while porosity frequently occurred without eburnation. This suggestion supports the research hypothesis that porosity often precedes lipping and may be due to other factors besides DJD, for example increased vascularization to the subchondral bone.

A significant part of this research that helped to answer questions on DJD was the application of other studies both within this collection and outside of it, in order to gain a better understanding of DJD. Lundin's (2000) and Ortner's (1966) study of DJD in the humerus were analyzed to see if a comparison could be made between what type of degeneration was occurring on the distal humerus compared with the proximal radius. Although the results were similar to those that were expected, they confirmed the presence of DJD, and the fact that both systemic as well as functional stress factors contributed to DJD. As a result, subsistence activities and the lifestyle of the people of this time period and geographic area play an important role in the expression of DJD.

Other Poole-Rose Ossuary Results

Data from the radius and humerus can be compared for a more comprehensive understanding of DJD, and can also be used to analyze if and why certain degenerative features co-occur, and in the stages of progression they go through. In Lundin's (2000) study on the humerus in the Poole-Rose ossuary, the trochlea was found to be the most frequently affected by degenerative joint disease. Lundin found that distal joint specimens were affected about 20% more than proximal specimens. This find suggests an activity-based hypothesis where the elbow was engaged more often and regularly than the shoulder. Alternatively, it may also indicate that the elbow was overall more susceptible to trauma or injury than the shoulder joint. Based on the research of the radii and humerii of the Poole-Rose population, theoretically one could assume similar results on the ulnae of this same population. It might even be suggested by this research that if the distal surface were affected the most in all three categories (lipping, pitting, and eburnation), then perhaps the distal surface of the ulna would be more affected as well.

Kelly (2001) studied the carpal and metacarpal bones from the Poole-Rose ossuary and found DJD evenly distributed between the left and right bones. No eburnation was found on the metacarpal joint surface. The patterning of eburnation in the carpal bones followed an outer and lateral outline of the hand.

This suggests degeneration of the joint capsule between the carpal bones and the radius (Kelly, 2001).

In this study, the distal aspect of the radius was more affected in terms of frequencies for lipping, pitting, and eburnation. If a stress hypothesis is emphasized over systemic factors such as aging and metabolism, then we might be able to assume that this population of people was engaging in a wide range of activities. A high presence of DJD localized in one specific area may indicate a more habitual activity, where trauma or injury may be responsible for the onset of DJD.

Other Studies

Anderson (1964) in his analysis of the Fairty ossuary, found almost twice the incidence of DJD in the ulna as in the radius. He also found frequencies for DJD to be about the same for proximal and distal ends. Although the Fairty study parallels the Poole-Rose study in description and classification of DJD, the frequency of involvement overall and in regards to the separate joint surfaces differs slightly. One reason for this could be the classification system of DJD, which as discussed earlier can affect the decision to label a specimen as having DJD. In the Poole-Rose study, all pre-mortem pitting was recorded as such, and a large percentage of specimens showed some frequency of pitting alone. To an extent, bone can show some pitting, even if that particular individual was healthy.

Often, a researcher will choose to focus only on moderate and severe expressions of DJD in order to definitively label the disease as such. Based on the medical information that pitting can occur due to a number of factors not related to DJD (Sokoloff, 1969), it may be appropriate in this study to label DJD as such according to the presence of either one or more characteristics of DJD, or based on the moderate and severe categories only.

Anderson (1964) concluded that in the Fairty sample, there was a high incidence of DJD in the shoulder, hip, and clavicle, with a lower incidence of DJD in the elbow, wrist, and ankle. Variation was noted in the incidence of DJD at different joints, and the different incidence in two bones involved in the same joint articulation (radius and ulna). There was a minimal degree of difference, but still a difference in incidence between the right and left sides of the Fairty sample, which differs from the findings in the Poole-Rose ossuary. Anderson also found that degenerative changes can begin as early as young adults, depending on several factors, including genetic predisposition, health, repeated trauma or injury, and type of activities that made up daily life.

Werner et al. (1991) have analyzed the basic mechanics of the wrist joint and found that 63-87% of wrist force passes through the distal radius. The transmission of force through

the wrist causes increased wear and degeneration in the lunate, scaphoid, and distal radius (Werner et al., 1991). This is in agreement with the finding that the distal radius was affected more frequently than the proximal radius in the Poole-Rose ossuary. Jurmain (1990) came up with similar results in his study on degenerative disease in a prehistoric population from California. Degenerative joint disease was most prevalent in the first metacarpal (28.6%), with the scaphoid and lunate also being affected.

The types of activities this population was engaging in on a daily basis has great importance in terms of DJD. Subsistence activities revolved mainly around agriculture and fishing (Trigger, 1976). Duties were divided between the men and the women, with men responsible for work that often took them away from home for long periods of time. Female tasks were of a more domestic nature, where they were able to take care of children and attend to tasks closer to the village. This major distinction and division of labor in Huron society may explain differences in the expression of DJD among the sexes in skeletal remains where sex is known.

Women planted, tended, and harvested the crops, spending much of their time on their knees cultivating the soil and grinding corn (Trigger, 1976). Activities such as these might be responsible for the mechanical stress put on the elbow and

wrist joints as well as the knees. The men would hunt, fish, trade and often engage in warfare with other peoples (Trigger, 1976). Based on the sex-specific cultural responsibilities of men and women, one hypothesis might be to expect DJD to occur in different frequencies on particular joints, as well as uneven wear on the right and left side of the body for the different sexes. If the men were hunting with bow and arrow, then DJD would more than likely manifest itself on the dominant side of the body being used. Therefore, repetitive extension of the forearm could lead to degeneration at the elbow joint or at the articulation point of the radial head and the capitulum. This is in contrast to female activities such as corn grinding or planting, where you would expect to notice a somewhat more even distribution of degenerative changes. Once sex is determined in the skeletal remains of the Poole-Rose population, it will be interesting to note if a theory of sex-related activities are acting on the expression of DJD in the radius and forearm.

CHAPTER 4

CONCLUSIONS

The main objective of this study was to examine the expression and patterning of degenerative joint disease. Several hypotheses were tested concerning factors affecting the onset of DJD. Ideas were presented to suggest why certain patterns were found and what they might indicate about the activities in which these peoples were engaging on a daily basis. The analysis of humerii within the Poole-Rose ossuary complements the results of the radii. Other studies of DJD were utilized as a comparative method for evaluating DJD.

Research by others puts more emphasis on the stress or functional hypothesis of DJD affecting joints, although systemic factors such as age and nutrition play a significant role in DJD, especially in its initial changes and onset. A combination of systemic and mechanical factors is the best explanation for occurrence of DJD in the radii of the Poole-Rose ossuary. Previous research on the radius and elbow joint suggest some form of trauma or stress as responsible for the occurrence of DJD in the elbow. Overall frequencies and patterns in the current study parallel other research where the elbow is usually moderately affected.

Based on the data collected from adult radii, the Poole-Rose population showed results similar to what was expected. The results indicate that a combination of factors are involved in the onset and expression of degenerative joint disease. Although some type of trauma or stress is responsible for the mild expression of DJD, there is no indication that the Poole-Rose population was subjected to severe levels of mechanical stress. If considering only moderately and severely affected individual specimens, the overall frequency of DJD in the Poole-Rose ossuary is relatively low, with porosity being the most frequent type of degenerative change. Due to the low incidence of degenerative joint disease, one could assume that the Poole-Rose population was relatively healthy. The fact that few other ossuary studies focus specifically on DJD limits the comparisons.

In terms of DJD and its complex etiology, further research is needed to more closely examine the factors affecting individual joints. Two of the puzzling mysteries of DJD are why some elderly people never succumb to DJD, and why some individuals engaged in repetitive high impact physical activities show no signs of DJD. Other similar studies will hopefully provide more comprehensive demographic profiles of prehistoric peoples, providing researchers a chance to explore the health of those that lived before us. The difficulties in

understanding the diverse etiology of the disease, in addition to problems in classification and interpretation will continue to be a challenge for researchers.

REFERENCES CITED

- Anderson, JE (1964) The people of Fairty: an osteological analysis of an Iroquois ossuary. National Museum of Canada Bulletin 143: 28-129.
- Aufderheide, AC, and Rodriguez-Martin C (1998) The Cambridge Encyclopedia of Human Paleopathology. Cambridge: Cambridge University Press.
- Bass, WM (1987) Human Osteology: A Laboratory and Field Manual. Columbia, MO: Missouri Archaeological Survey.
- Bridges PS (1991) Degenerative joint disease in hunter-gatherers and agriculturalists from the Southeastern United States. American Journal of Physical Anthropology 85: 379-391.
- Bordelon BM (1997) Incidence of degenerative joint disease in the tibia of the Poole-Rose Ossuary. M.A. thesis, Louisiana State University, Baton Rouge.
- Brothwell DR (1981) Digging Up Bones: The Excavation, Treatment and Study of Human Skeletal Remains. Third edition. Ithaca, New York: Cornell University Press.
- Buikstra JE, and Ubelaker D (1994) Standards for Data Collection from Human Skeletal Remains. Arkansas Archeological Survey Series, No.44, Fayetteville, Arkansas.
- Churcher CS, and Kenyon WA (1960) The Tabor Hill ossuaries: a study in Iroquois Demography. Human Biology 32: 249-273.
- Dunne DE (1999) Health in the Poole-Rose ossuary population: An analysis of vertebral body pathology. M.A. thesis, Louisiana State University, Baton Rouge.
- Gray, H (1974) Gray's Anatomy. Philadelphia: Running Press, pp.144-158.
- Harris, RI (1949) Osteological evidence of disease amongst the Huron Indians. University of Toronto Medical Journal 27:71-75.
- Jurmain RD (1977) Stress and etiology of osteoarthritis. American Journal of Physical Anthropology 46:353-366.

- Jurmain RD (1978) Paleoepidemiology of degenerative joint disease. *MCV Quaterly* 14:45-56.
- Jurmain RD (1980) The pattern of involvement of appendicular degenerative joint disease. *American Journal of Physical Anthropology* 53:143-150.
- Jurmain RD (1990) Paleoepidemiology of a Central California prehistoric population from CA-ALA-329:II. Degenerative disease. *American Journal of Physical Anthropology* 83:83-94.
- Jurmain, RD (1999) *Stories from the Skeleton: Behavioral Reconstruction in Human Osteology*. Amsterdam: Gordon and Breach Publishers.
- Kelly, SM (2001) Demography and health of the Poole-Rose population based on an analysis of the carpal and metacarpal bones. M.A. thesis, Louisiana State University, Baton Rouge.
- Kidd KE (1953) The excavation and historical identification of a Huron ossuary. *American Antiquity* 18:359-379.
- Kirk, R (1990) *Statistics: An Introduction*. Third Edition. Fort Worth: Holt, Rinehart, and Winston, Inc., pp. 531-564.
- Knight, D, and Melbye J (1983) Burial patterns at the Ball site. *Ontario Archaeology* 40:37-48.
- Lundin D (2000) Evidence of osteoarthritic alterations to the proximal and distal joints of the humerus: Analysis of skeletal remains from the Poole-Rose Ossuary. M.A. thesis, Louisiana State University, Baton Rouge.
- McKillop H, and Jackson L (1991) Discovery and excavations at the Poole-Rose Ossuary. *Arch Notes* 91:9-13.
- Ortner DJ (1966) Description and classification of degenerative bone changes in the distal joint surfaces of the humerus. *American Journal of Physical Anthropology* 28:139-156.
- Ortner, DJ, and Aufderheide AC, eds. (1991) *Human Paleopathology: Current Syntheses and Future Options*. Washington: Smithsonian Institution Press.

- Pfeiffer S (1983) Demographic parameters of the Uxbridge ossuary population. *Ontario Archaeology* 40:9-14.
- Pfeiffer S (1985) Paleopathology of archaic peoples of the Great Lakes. *Canadian Journal of Anthropology* 4 (2):1-7.
- Radin EL (1993) Osteoarthritis In V Wright and EL Radin (eds.): *Mechanics of Human Joints*. New York: Marcel Dekker, Inc., pp. 341-353.
- Rothschild BM, and Woods RJ (1992) Osteoarthritis, calcium pyrophosphate deposition disease, and osseous infection in Old World Primates. *American Journal of Physical Anthropology* 87: 341-347.
- Rothschild, BM (1997) Porosity: A curiosity without diagnostic significance. *American Journal of Physical Anthropology* 104: 529-533.
- Seidemann E (1999) Analysis of the nonmetric traits of the Skull in the Poole-Rose ossuary, Ontario, Canada. M.A. thesis, Louisiana State University.
- Smith HJ (1997) Health in the Poole-Rose ossuary population: A look at cribra orbitalia and porotic hyperostosis. M.A. thesis, Louisiana State University, Baton Rouge.
- Sokoloff L (1969) *The Biology of Degenerative Joint Disease*. Chicago: University of Chicago Press.
- Tague RG, Manhein M, and McKillop H (1998) Paleodemography of the Poole-Rose ossuary. *American Journal of Physical Anthropology Supplement* 26:214-215.
- Tooker E (1964) *An Ethnography of the Huron Indians, 1615-1649*. Bureau of American Ethnology, Bulletin 190. Washington, D.C.: Smithsonian Institution Press.
- Trigger, BG (1976) *The Children of Aataentsic I: A History of the Huron People to 1660*. Montreal: McGill-Queen's University Press.
- Wells, C (1964) *Bones, Bodies, and Disease: Evidence of Disease and Abnormality in Early Man*. London: Thames and Hudson.

Werner FW, An KN, Palmer AK, and Chao EY-S (1991) Force Analysis. In An KN, Berger RA, and Cooney WP (eds.) Biomechanics of the Wrist Joint. New York: Springer and Verlag, pp.77-97.

White T (2000) Human Osteology, Second Edition. San Diego, California: Academic Press.

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