Demography, health status, and mortuary rituals of the late Woodland Poole-Rose ossuary, Ontario, Canada: a study of the clavicles

Nicole Elizabeth Smith
Louisiana State University and Agricultural and Mechanical College, turelie26@gmail.com

DEMOGRAPHY, HEALTH STATUS, AND MORTUARY RITUALS OF THE LATE WOODLAND POOLE-ROSE OSSUARY, ONTARIO, CANADA: A STUDY OF THE CLAVICLES

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ABSTRACT

This thesis is an analysis of the clavicles from a pre-contact (1550 A.D. ±50 years) native ossuary burial from Ontario, Canada. The Poole-Rose ossuary clavicles were analyzed for demography, pathological processes, trauma, and cultural modifications. Demographic markers on the clavicles are derived from the minimum number of individuals (MNI) estimation, medial epiphyseal age, and sex. Pathological processes are indicated by the presence of degenerative joint disease (DJD), periosteal reactions, and lytic lesions. Trauma includes healed fractures and cuts from defleshing of the clavicles. The presence of pre-burial cut marks is an indication of cultural modifications that were likely part of a ritual ceremony similar to the Huron "Feast of the Dead."

An MNI of 196 individuals was determined based on the right lateral epiphysis of the clavicle. A very significant amount of DJD was present in the acromioclavicular joint as compared to the sternoclavicular joint. Active periosteal reactions of the clavicle were more frequent than healed reactions. Clavicular lesions were significantly associated with adult individuals, but tended to affect the side and joint of the bone to similar degrees. Healed fractures of the clavicle were rare in the ossuary population. Cut marks tended to consist of fewer than 10 cuts on major muscle attachment sites. A very significant association existed between the presence of a rhomboid fossa and age of the individual.

The metric analysis of the Poole-Rose ossuary clavicles includes similar correlations between length and robusticity of both left and right bones. However, right bones were more variable in curvature than left bones, possibly owing to general right-handedness. Size differences between mean metric values of left and right clavicles were not significant.

Based on the clavicle, the population seems to have been in general good health, with unusually low rates of antemortem injury. However, the existence of clavicular lesions suggests

some instance of disease in a few individuals. Variable right curvatures of the clavicle could indicate a preference for right-handedness in the population. Future research of other Poole-Rose ossuary bones may yield insight into the clavicular traits brought to light in this study.

CHAPTER ONE: INTRODUCTION

Human osteology, in its many forms and facets, uses the physical characteristics of the human skeleton to deduce qualities of that particular human in life. Given adequate presence and preservation of a human skeleton, the osteologist can assign sex, age, and stature to a skeletal individual, as well as suggest ancestry, health, and activity patterns during life. Similarly, at the population level, demography, health, and cultural activities can be suggested by the combined qualities of an associated group of skeletons.

To glean information about the health of a skeletal individual in life, the researcher performs a paleopathological analysis. Paleopathology involves the identification of disease processes by their effect on the skeleton. Typically, the bone responds to stimuli by either adding or removing bone mass in affected areas. The paleopathologist attempts to identify the pathology causing the bone changes through comparison with past and present knowledge about the disease.

Trauma is another important aspect of osteological analysis that can provide information about the individual. The researcher must distinguish between trauma that occurred before death, around the time of death, and after the death of the individual. Healed trauma that occurred during the life of the person (antemortem) can yield information about the activities in which the person was involved. Trauma experienced around the time of death (perimortem) offers clues to the circumstance under which the individual died. Postmortem (after death) trauma can include alterations from animal activities, environmental damage, and in some cases, human alterations to the bone. The last postmortem trauma provides cultural information into the mortuary rituals practiced by a particular population.

The goal of my project is to extract evidence of population-based ways of life and death from the clavicles of a pre-contact ossuary burial from Ontario, Canada. The Poole-Rose ossuary clavicles were analyzed for pathological processes, healed trauma, demography, and cultural modifications. Degenerative joint disease and destructive lesions of skeletal tuberculosis were predicted to appear on the clavicles of this population, based on the presence of these pathologies on other Poole-Rose ossuary bones (Dunne, 1999; Baumer, 2008). Additionally, cultural modifications of bone caused by ritual defleshing ceremonies appear on many bones in the ossuary (Kelly, 2001; Bodin, 2002; Schiess, 2002; Penney, 2005; Baumer, 2008) and were expected to be present on the clavicle as well. Owing to the prevalence of clavicular fractures in modern populations, healed fractures of the ossuary clavicles were also expected to be common. Mechanical loading of the shoulder was anticipated to have caused greater clavicular curvatures, especially for the side of the body most frequently used in the activity (i.e. handedness). In this thesis, I present the results of the Poole-Rose ossuary clavicle analysis.

CHAPTER TWO: LITERATURE REVIEW

2.1 Background of the Poole-Rose Ossuary

An ossuary is a secondary burial pit, typically used by Native American tribes to relocate large numbers of deceased individuals that were previously contained elsewhere (Ubelaker, 1974). The relocating event often is associated with ritual activities performed by the tribe to honor the dead they are interring. The remains are in various states of decomposition when this event occurs, but the majority are skeletonized. The disarticulation of the skeletal remains, as well as the process of disturbing the previous arrangement of bones in their initial resting place, results in the commingling and disassociation of human remains in the ossuary.

Although the commingled skeletal remains cannot be assessed accurately at the level of the individual, they can provide information about the population as a whole. Combined with historical, ethnographic, and archaeological evidence, a reasonable estimate of population demography can be assessed from the ossuary material (Ubelaker, 1974). Health and prevalence of infectious disease within the population can also be suggested from the presence of skeletal changes in ossuary bones. Furthermore, cultural habits and activities of the population can be implied from the severity of skeletal joint changes and wear facets. Therefore, the study of skeletal material from ossuaries provides an opportunity to glean information about demographics, paleopathology, and cultural practices of the groups which they represent.

The Poole-Rose ossuary was discovered accidentally in the summer of 1990 on a private farmhouse property in southern Ontario, Canada, by workers digging a piping trench. The ossuary was subsequently excavated in 1990 by Heather McKillop and a team as per the request of the Alderville First Nation (McKillop and Jackson, 1991). The Alderville First Nation wished for the remains to be studied to learn biological and cultural information before reburial at Alderville. The burial pit style of this ossuary was common for Iroquoian burials in the Late

Woodland period (McKillop and Jackson, 1991). Radiocarbon dating from the site placed it within the range of the year 1550 A.D. ±50 years. The ossuary site measured two and one-half meters in diameter with a maximum depth of one and one-half meters. It contained the skeletal remains of an estimated several hundred disarticulated individuals and three "flexed" individual burials (McKillop and Jackson, 1991). The highest estimate of minimum number of individuals in the ossuary is 337, based upon the right petrous portion of the skull (Seidemann, 1999), with approximately 24% being subadults under the age of 15 (Tague et al., 1998).

The cultural significance of the ossuary appears to have been connected with a "Feast of the Dead" ritual, which has been described in one ethnographic account of the Huron (Thwaites, 1896-1901; McKillop and Jackson, 1991; Tague et al., 1998). Unlike the accounts of Huron ossuary burial, however, the Poole-Rose ossuary included the remains of infant children and is not located in Huron territory (McKillop and Jackson, 1991). Although there is no positive association of the Poole-Rose ossuary to a particular native cultural group, the marks of defleshing suggest the population may have shared cultural similarities with the Huron. The Poole-Rose ossuary was created by Late Woodland agriculturalists, and contained no material remains (Personal communication, Heather McKillop, 2010).

2.2 Late Woodland History and the Feast of the Dead

Five Late Woodland ossuaries in southern Ontario, Canada, have been fully excavated and studied (Warrick, 2008). They include the ossuaries of Moatfield (1290-1320 A.D.), Fairty (1320-1350 A.D.), Uxbridge (1450-1480 A.D.), Kleinburg (1570-1600 A.D.), and Ossossané (1623-1636 A.D.). Figure 2.1 shows the geographical distribution of the ossuaries, along with the location of the Poole-Rose ossuary.

Most of what we know about the Huron people as they existed during the contact period comes from the French Jesuits who did missionary work in Huron villages. A Jesuit priest named Jean de Brébeuf wrote the largest body of information on the Huron during his 20 years of missionary service with them from August, 1626, to March, 1649 (Thwaites, 1896-1901; Donnelly, 1975). He was also able to view and provide the only eyewitness account of the Huron "Feast of the Dead" event.

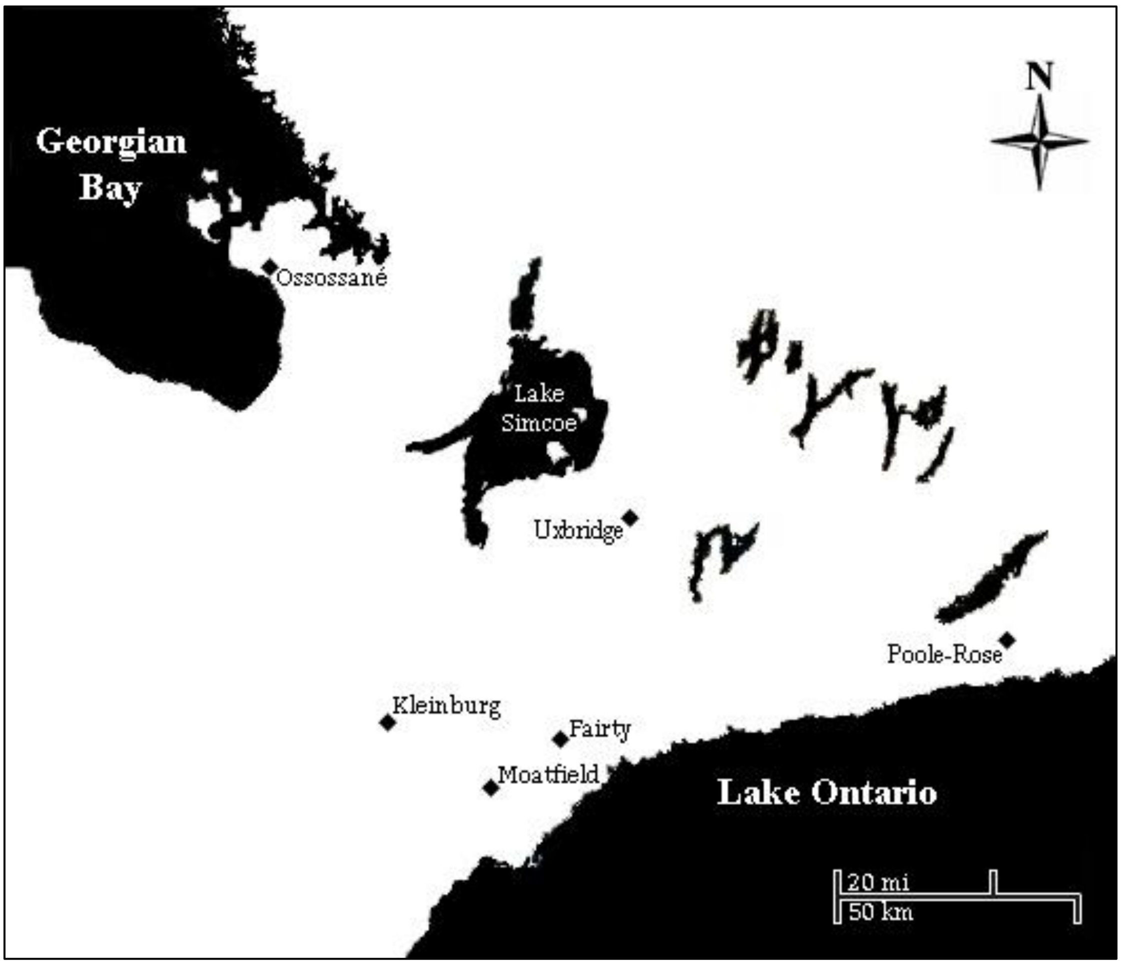

Figure 2.1 Location of the Poole-Rose Ossuary with Other Late Woodland Ossuaries. Adapted from Warrick (2008) and McKillop and Jackson (1991).

At the time of European contact with the Huron in the early 17th century, the tribe was a sedentary agriculturalist culture group of about 30,000 individuals whose land bordered with

Lake Huron's Georgian Bay and Lake Simcoe, Ontario, Canada. Although called the Huron by the French for their non-European hairstyles, the culture group called themselves the Wendat, or "people of the island," probably owing to their geographical near-seclusion (Donnelly, 1975). Their diet consisted of the typical food staples of corn, beans, and squash common in North American agricultural groups. They also hunted, fished, gathered wild fruits, and grew sunflowers for their seeds to supplement their diet. Much of their survival depended on the trade alliances they had with the Ottawa and Algonquians to the North and Petuns and Neutrals to the South, passing on commodities such as corn, tobacco, hemp, pelts, and dried fish while taking a percentage of these for themselves (Thwaites, 1896-1901; Donnelly, 1975).

The accounts of Father Brébeuf and other Jesuits note the overall good health status of the Huron communities they frequented (Thwaites, 1896-1901; Donnelly, 1975). Skeletal remains, however, suggest the prevalence of some expected pre-contact diseases such as tuberculosis, treponemal infection, dental caries, and periodontal disease. During the first half of the 17th century, post-contact epidemics of European diseases, primarily smallpox and measles, took a major toll on overall health of the population. The population size, of around 30,000 individuals in the early 17th century, had dwindled to a mere 12,000 individuals by the year 1649 (Warrick, 2008).

The Huron death rituals involved a practice called "the Kettle" or "Feast of the Dead," which typically only took place once every twelve years (Thwaites, 1896-1901; Donnelly, 1975). Throughout the intervening years, whenever someone died, the family members would place the body in a separate building structure within the "cemetery" near the village, which consisted of an enclosed scaffold meant to keep scavenging animals away from the remains (Thwaites, 1896-1901; Tooker, 1964). Eventually, numerous bodies of deceased persons in various states of decomposition accumulated in this cemetery until impending village migration, due to soil nutrient depletion and refuse accumulation, compelled the observance of the Feast of the Dead ceremony. At that time, the surviving family members extracted the mostly-skeletonized remains from their individual scaffolds, removed any remaining tissue from the bones, and bundled the clean bones in skins (Thwaites, 1896-1901; Donnelly, 1975; Tooker, 1964). Finally, the villagers trekked to a designated location to rebury their bundled relatives in a common, commingled grave-pit. The Huron left intact the recently-deceased individuals and placed them at the bottom of the ossuary around three central kettles (Thwaites, 1896-1901; Donnelly, 1975; Tooker, 1964). In historic ossuaries, they laid grave goods down in the pit and unbundled the bare bones of the rest of the dead, letting them fall down into the grave (Thwaites, 1896-1901; Sagard, 1939). However, prehistoric ossuaries do not contain any grave goods or other material remains (Personal communication, Heather McKillop, 2010). Tree bark and skins lined the ossuary and they backfilled it with soil. The Huron did not rebury in the ossuary persons who died of unnatural or violent causes because they did not believe these individuals had contact with their souls in the afterlife. Infants who died were buried next to a road so that their spirit could be reborn in the womb of a woman passing by (Thwaites, 1896-1901; Tooker, 1964).

2.3 Health and Infectious Disease

Disruption in the normal health of an individual, either by a drawn-out pathological infection, or other condition at a progressed stage can affect the balance of bone maintenance, thus, causing either formation of new bone or resorption of bone at a faster pace (Steinbock, 1976). Inflammation of the periosteum, or thin layer of nerves and tissue covering the bone shaft, due to trauma or a disease process, causes the underlying bone to form new bone on top of the cortical surface. Periosteal reactions in bone typically result in periostitis or osteomyelitis depending on the presence and location of pyogenic bacteria in relation to the bone. Periostitis affects only the cortex of the bone, without disrupting the medullary canal. Conversely, osteomyelitis causes similar reactive bone, but typically invades the medullary canal. The superficial position of the clavicle in the human body makes this bone a common site for periosteal reactions that spawn from surface trauma or skin lesions such as those produced by staphylococcal and treponemal infections (Steinbock, 1976).

Skeletal tuberculosis causes lesions that destroy cancellous bone. This type of destructive lesion may be seen visually or radiographically. The main distinction between characteristic tubercular lesions and those of other disease processes is the cavitation of cancellous bone with little to no surrounding reactive bone (Ortner, 2003). Tubercular lesions and destruction of the sternal articular surface can sometimes appear on the clavicles, as they are located in close proximity to the lungs (Kelley and El-Najjar, 1980; Pfeiffer, 1984). Lesions and joint degeneration sometimes affect the acromioclavicular joint as well, but much less so than other, larger joints (Ortner and Putschar, 1981). A study performed by Alfer in 1892 (as cited in Ortner, 2003) showed that of 1752 tuberculosis cases, only two cases presented clavicular lesions. Joint lesions of the same sample were more frequent in the sternoclavicular joint than in the acromioclavicular joint, with an affected case ratio of four to one, respectively.

The analyses of health for the Poole-Rose ossuary population have shown that these individuals were healthy. Penney (2005) noted a few instances of unexplained disease-related resorptive lesions affecting a few calcanei (heel bones). Dunne (1999) and Baumer (2008) described lesions characteristic of tuberculosis on a small percentage of the vertebrae and ribs, respectively. Baumer also found periosteal reactions of various stages of severity on the ribs in the ossuary. Since bone lesions caused by tuberculosis infections are estimated by Pfeiffer (1984) to affect only one to seven percent of cases, the small number of lytic lesions found in the ossuary could represent the infection of tuberculosis for a much larger proportion of the population.

Physiological stress is another indicator of health within a population that can manifest itself on the skeleton. Iron-deficiency anemia resulting from nutritional deprivation or parasitic infestation affects the flat bones of the skull through processes of marrow overproduction and responsive cortical replacement with cancellous bone (Larsen, 1997). This bone manifestation is known as porotic hyperostosis when present on the cranial vault and cribra orbitalia when on the orbital roof. Smith (1997) reported a high rate of iron-deficiency anemia in the Poole-Rose population. She found cribra orbitalia in 40.7-67.5% of individuals and porotic hyperostosis in 11.8%. This finding likely can be attributed to the crowded living conditions of Late Woodland people and the resulting low sanitation and high incidence of parasitic infection. Another possible hypothesis is the low nutritional value of the Late Woodland maize-based agricultural diet, which, lacking in substantial meat consumption, would have caused an increase in iron-deficiency anemia (Larsen, 1997).

Similar to anemia, physiological stress during childhood can also cause the human body to shut down its normal bone-building processes, resulting in characteristic lines of bone disruption (Larsen, 1997). These are prominent in the tooth enamel as lines of hypoplasia and in the tibiae as transverse or Harris lines. Listi (1997) analyzed radiographs of Poole-Rose ossuary tibiae and found many instances of Harris lines, which she believed suggested the presence of nutritional stressors in an otherwise healthy population.

2.4 Degenerative Changes and Activity Markers

Degenerative joint disease (DJD), also known as osteoarthritis, reflects the breakdown of cartilage at joint surfaces and the bony responses that follow (White and Folkens, 2005). According to the degenerative progression of the joint, the bone generally responds in three different ways: bony proliferation, porosity, and eburnation. Bony proliferation refers to the reactive bone spicules called osteophytes that extend from the edges of joint surfaces of bone.

Porosity indicates the small openings produced in subchondral bone as the cortex (outer bone layer) wears away. Eburnation represents the polished surface of subchondral bone that results from direct contact of opposing bone surfaces of the joint following the destruction of the cartilage that separates them (White and Folkens, 2005). An increase in age or activity level associates with increases in severity and location of the joints affected by DJD.

Many studies have tried to explain the factors influencing degenerative joint disease in populations. Jurmain (1977) analyzed bones from modern American white, modern American black, prehistoric American Indian from Pecos Pueblo, and proto-historic Alaskan Inuit populations to find that degenerative joint disease occurs as a multifactorial culmination of age, sex, ancestry, and functional stress to a joint. Functional stress to particular joints through repeated activity patterns was given the most weight in this study, but Jurmain emphasized the importance of the other factors to the onset of DJD. Bridges (1991) compared DJD in prehistoric Alabama agriculturalist and hunter-gatherer populations to suggest the effect of subsistence-specific functional stress to joints. Her results showed slightly more DJD in the Archaic foraging population than the agriculturalist population. She suggested that repetitive activities may cause diaphyseal strengthening, and that infrequent strenuous activities may be the culprit of joint degeneration.

Within the Poole-Rose population, the limb bones display minimal but often unevenly located degenerative changes, possibly suggesting activity-related stress to the joints as a cause. Bordelon (1997) analyzed the tibiae and found the lateral condyle of the right proximal tibia to be most commonly affected by DJD. Dunne (1999) found that 37.83% of vertebrae in the Poole-Rose ossuary contain osteophytic “lipping,” which was most likely age related or a result of the infection she noted within the population. Lundin (2000) found that the distal joint of the humerus, particularly the trochlea, was more frequently affected by DJD, suggesting the elbow was more active than the shoulder. Kelly (2001) saw degenerative changes in the carpal and metacarpal bones from the ossuary that were equally distributed between right and left hands. The DJD in the hand seemed to focus on the articulation with the radius, which Parks (2002) examined. Parks found that the distal radius was more commonly affected than the proximal, supporting Kelly's findings. Conversely, Bodin (2002) found more DJD on the proximal ulna than the distal, which matches Lundin's findings of arthritis in the humerus focused at the elbow. Penney (2005) reported a very small amount of DJD in the calcaneus and talus bones of the foot. Finally, Baumer (2008) found a minimal amount of DJD in articular facets of ribs, with the right seeming to be affected more than the left.

2.5 Trauma

Most of the trauma to bones in the Poole-Rose ossuary appears to have occurred after the death of the individuals, possibly during the Feast of the Dead ritual. This postmortem trauma includes cut marks from the removal of dried tissue from bones and weathering and fragmentation processes from the subsequent mass burial in the ossuary pit. Cut marks are caused by a sharp, manufactured implement and distinguished by their fine, narrow appearance on the surface of the bone (White and Folkens, 2005).

In addition to the postmortem trauma, healed or unhealed trauma to the bones that occurred during the life of these individuals may be present. The clavicle is the most commonly fractured bone in both children and adults today, most likely due to its position and function as a strut and shock absorber for the shoulder joint (Bolte, 2004). Of the clavicle fractures in children, nearly half of these occur in children under the age of seven (Basamania and Rockwood, 2009). In clinical settings, clavicle fractures represent about five to ten percent of all fractures (Robinson, 1998). Additionally, about 44% of shoulder girdle injuries involve fractures of the clavicle (Basamania and Rockwood, 2009). The Late Woodland people likely experienced a similarly high degree of clavicular fractures within their population.

Clavicular fractures fall into one of three categories based on their location: sternal end, midshaft, and acromial end (Allman, 1967). The most common of these fractures is the fracture to the midshaft of the clavicle, often resulting from a fall and subsequent impact to an outstretched hand or directly to the shoulder. Following midshaft fractures in prevalence is the lateral (acromial) end of the clavicle, usually fractured by a downward impact force to the point of the shoulder. The least common area of clavicle fracture is the medial (sternal) end, which is often caused by a violent blow to the specific location of fracture (Allman, 1967; Throckmorton and Kuhn, 2007). In modern times, vehicular accidents account for most adult clavicle fractures (Basamania and Rockwood, 2009). Impact from falls is the mechanism of fracture most common in children and elderly individuals, as well as accounting for a portion of adult fractures (Bolte, 2004; Nordqvist and Petersson,1995). The Late Woodland people would likely have experienced clavicle fractures resulting mostly from falls and violent injury similar to the non-vehicular fractures common today.

Following a fracture, bone tends to heal in a predictable process in which the pace of repair depends upon the age and health of the individual. Fractures proceed through three repair stages: inflammatory, reparative, and remodeling (Rodríguez-Martín, 2006). The inflammatory stage involves the processes of hematoma formation and soft tissue repair directly after the trauma event; no bony response occurs at this stage. The reparative stage includes the formation of a fibrous callous of cartilage (usually present by the third week), osteogenic reaction of fracture surface, and subsequent process of calcification of the callous that begins after a period of three weeks has passed. The bone can be in this stage for a few weeks to several months. The final stage of bone remodeling includes the months and possibly years after the trauma event in which the callus ossifies and takes part in the gradual bone remodeling processes. From these chronological stages of bone repair, antemortem trauma is distinguishable from perimortem trauma, and a relative time since fracture can be estimated in recent antemortem fractures.

Nowak (2002) published a long-term study that followed patients with clavicle fractures in Uppsala, Sweden. He found that about half of patients healed completely within six months of their injury, with a median healing time of four months and a minimum of three months. He also noted shortening in clavicles with healed fractures relative to their unfractured paired clavicle, but acknowledged the presence of normal clavicle length discrepancies in individuals may cause error in determination of shortening due to injury.

2.6 Metric Variation

Metric analysis of the clavicle can suggest identifying factors such as sex, stature, and handedness, but inter- and intra-individual variation can make many of these estimates error prone. Variation in paired clavicle size with regard to length and robusticity commonly shows a shorter length in right clavicles as compared with their left counterpart (Mays et al., 1999). In their 1999 study, Mays and coauthors reviewed various hypotheses as to the cause of this size discrepancy. The most likely hypothesis they found was that clavicle length on the dominant side of the body tended to be shorter because of mechanical loading and compression of the clavicle in correspondence with more muscle development that limits clavicular growth and development. This hypothesis was validated by the greater asymmetry patterns in adult clavicles than those of juveniles in the study group, as well as the larger muscular attachment sites on the shorter of the paired clavicles (Mays et al., 1999). According to their findings, length discrepancies in paired clavicles can be indicative of handedness of the individual, as the dominant side was that of the shorter clavicle.

With regard to sex, theoretically, length and robusticity are the telltale characteristics. Longer, more robust clavicles with prominent muscle attachments tend to be from males, whereas the opposite characteristics tend to correspond with bones from females. In practice, however, using clavicular dimensions to determine sex does not often offer reliable consistency with correct outcomes. Jit and Singh (1966) found that sex determined by clavicular length is accurate in eight to 20% of males and 12-14% of females. Sex determination by clavicular weight was somewhat more reliable for males at 24-35% accuracy, but less in females at zero to two percent. Midshaft circumference of the clavicle can determine sex in 48-72% of males, but only five to ten percent in females (Jit and Singh, 1966). Shirley et al. (2009) demonstrated through methods of linear discriminant functions, artificial neural networks (computational model), and angle/curvature analysis methods that the clavicle can be assessed for sex with up to a 94.58% accuracy rate. Metric points consisted of maximum length, sagittal midshaft diameter, vertical midshaft diameter, maximum midshaft diameter, minimum midshaft diameter, two diameters from the lateral end, and two diameters from the medial end, as well as medial shaft points to determine angle. The authors recommended a combination of all three methods for higher accuracy (Shirley et al., 2009).

Use of the clavicle to determine stature has not proven to be an accurate measure when used singularly (Jit and Singh, 1956). Longer clavicle length theoretically should correlate with taller stature, but the high rate of error incurred in this method likely results from the metric variance of the factors discussed in the preceding paragraphs. The pressures placed on growth and development of the clavicles are unique for every individual, regardless of stature.

2.7 Non-metric Variation

The clavicle has several more visual features that can lead to estimation of identifying characteristics for an individual. Unique in ossification patterns, the clavicle is the first bone to begin ossification in-utero, but often the last to complete fusion of its epiphysis (Bass, 2005). The medial epiphysis at the sternal end of the clavicle can take anywhere from 16 to 30 years to fully fuse in males and 16 to 33 years in females (Webb and Suchey, 1985). The age ranges for medial clavicle epiphyseal union tend to vary slightly over populations and ancestries; therefore, population-specific data are useful when estimating age from the stage of epiphyseal closure (Baccino and Schmitt, 2006). Unfortunately, none of the published clavicle fusion age studies have included a sample from First Nations people of Canada.

Several studies have reported age ranges for medical clavicle fusion based on various sample populations: early 20th century American whites and blacks (Stevenson, 1924; Todd and D'Errico, 1928), American male Vietnam War dead (McKern and Stewart, 1957), a multi-ancestral sample from the late 1970s (Webb and Suchey, 1985), and an 18th and 19th century European sample (Black and Scheuer, 1996). Webb and Suchey's (1985) study represents the widest age range of the epiphyseal union studies and the only study that included individuals of Latin American and Asian ancestry. Since both of these ancestries, as well as the ancestry of First Nation people from Canada, fall under the broad category of Mongoloid, Webb and Suchey's (1985) age range may represent the closest estimation of medial clavicle fusion age for First Nation populations.

The presence of a rhomboid fossa on the inferior surface of the medial diaphysis of the clavicle has been linked with sex and age of the individual (Rogers et al., 2000). This trait appears larger and more pronounced in young adult males than older males, and males are far more likely than females to have a rhomboid fossa. The utility of the rhomboid fossa in identification of unknown remains is limited, as the authors caution against using it as the singular source of sex or age estimation. However, the presence of a rhomboid fossa can lend support to the findings of other means of estimation for age and sex.

CHAPTER THREE: MATERIALS AND METHODS

For this study of the Poole-Rose ossuary clavicles, health status, demography, and cultural modifications of the bones were assessed. Many of the ossuary clavicles had already been cleaned and reconstructed prior to the present study. Any associable clavicle fragments were reconstructed. Clavicles were separated according to side, portion present, and epiphyseal fusion stage prior to analyses. Non-metric analysis included whole and fragmentary clavicles; however, for accuracy, the metric analysis only included the whole clavicles.

Clavicles from adults were distinguished from clavicles from juveniles based on Webb and Suchey's (1985) stages of medial clavicle epiphyseal union. Clavicles with a partial epiphyseal union were considered to be young adults. The presence of a rhomboid fossa was noted, but only served to corroborate other methods of age and sex estimation. A rhomboid fossa in this sample was defined by a distinct depression that perforated the cortical bone of the costoclavicular ligament attachment site. Impressions with ambiguous degrees of depressed cortical bone were not included in the rhomboid fossa count.

Table 3.1 Stages of Medial Clavicle Epiphyseal Union. Adapted from Webb and Suchey (1985).

Stages of Union	Males	Females
Nonunion with or without separate epiphysis	< 26 years	< 24 years
Partial union	17-30 years	16-33 years
Complete union	21+ years	20+ years

Instances of DJD, periosteal reactions, infectious lesions, and healed fractures were scored for severity using standard systems of classification from Buikstra and Ubelaker (1994). Instances of clavicle pathologies were photographed and viewed microscopically at 25x magnification. DJD of the medial and lateral articular facets of the clavicle was scored using three stages of severity. Clavicles lacking more than half of the joint surface were not included for the estimation of overall prevalence of ossuary DJD to avoid assigning an incorrect severity stage. Caution was taken in the distinction between arthritic pitting and the bone porosity associated with cortical weathering. Clavicles of indistinguishable porosity were considered unobservable and not included in the count of arthritic clavicles.

Periosteal reactions on the clavicles were evaluated conservatively; only those bones with obvious cortical inflammatory response were considered as having this reaction. This cautious consideration excluded clavicles with the possibility of weathering-related striations to the cortical bone. Present reactions were viewed microscopically at 25x magnification and described as either active or healed at the time of death. Lesions were scrutinized microscopically at 25x magnification to affirm the percentage of bone affected by the lesion and the amount of healing response. When noted either visually or radiographically, fracture calluses were classified according to their location and the degree of remodeling present. Each clavicle was viewed microscopically at 25x magnification for cut marks. Color of the bone was used to distinguish between the white cuts from trowel damage at excavation and the dark, soil-stained cuts made prior to ossuary burial. Cut marks were recorded according to appearance, frequency, and location on the shaft.

The metric analysis consisted of measurements taken (in millimeters) for clavicular maximum length, sagittal midshaft diameter, vertical midshaft diameter, as well as medial shaft points to determine angle. Clavicular measurement procedures followed those of Moore-Jansen et al. (1994) and Mays et al. (1999). In order to reduce potential measurement error, only those clavicles with minimal damage to epiphyses were included in the metric analysis. Maximum length measured the greatest space between medial and lateral aspects of the clavicle using an osteometric board (Figure 3.1). Sagittal and vertical diameters measured the horizontal and vertical width of the bone respectively at the metric midpoint (one-half of the maximum length) using sliding calipers (Figures 3.2 and 3.3). Clavicle medial and lateral curvature were obtained using a metric ruler on clavicle x-rays to measure the point of deepest curvature (Figure 3.4).

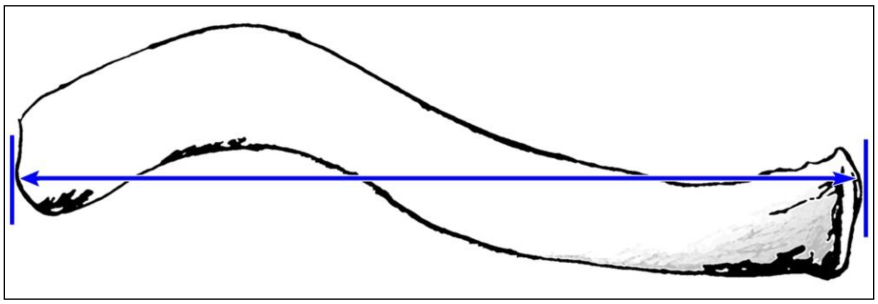

Figure 3.1 Maximum Length of the Clavicle. Drawn by Nicole E. Smith.

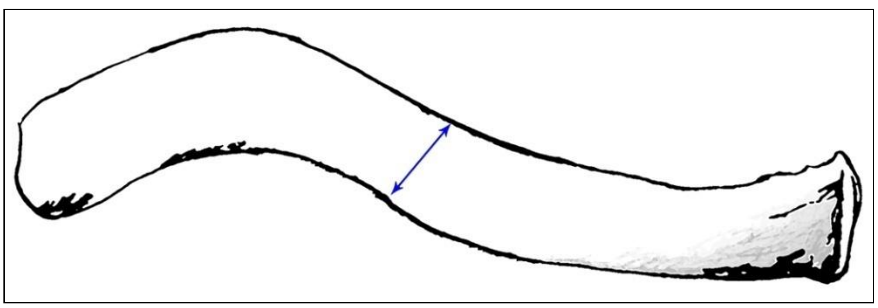

Figure 3.2 Sagittal Diameter of the Clavicle at Midshaft. Drawn by Nicole E. Smith.

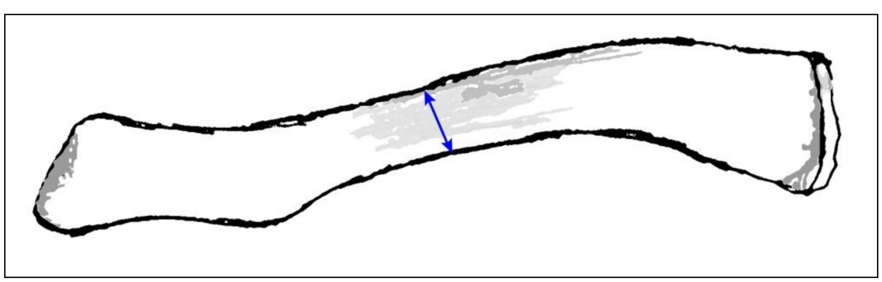

Figure 3.3 Vertical Diameter of the Clavicle at Midshaft. Drawn by Nicole E. Smith.

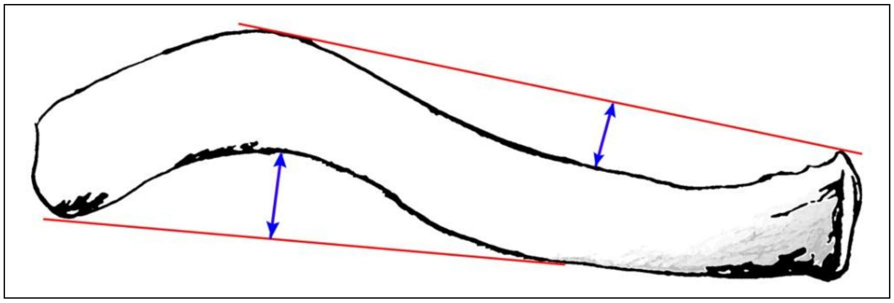

Figure 3.4 Maximum Lateral and Medial Curvatures of the Clavicle. Drawn by Nicole E. Smith.

Metric values were entered into Fordisc 3.0, a computer program that uses discriminant functions from identified forensic case metric dimensions to denote sex and ancestry by comparison to the metric dimensions of unknown skeletal remains (Ousley and Jantz, 2005). Although Fordisc applied a sex estimation to each clavicle, the validity of the estimation is unknown because of the discrepancies in ancestry and type of material; a modern white/black forensic population is used for postcranial comparison in Fordisc, whereas the ossuary consists of an archaeological First Nation population from Canada.

Finally, a statistical analysis was performed to determine the significance of data trends. Pearson's chi-square and Fisher's exact tests were used to compare associations between non-metric categorical values. Pearson's correlation coefficients were used to compare metric values of individual clavicles per side. A Student's t-test was performed to compare differences in the metric values of right with left clavicles. A 95% confidence interval was used to denote significance for all tests.

CHAPTER FOUR: RESULTS

A total number of 553 whole and fragmented clavicles was analyzed in this study. This total consisted of 65 clavicles from subadults with unfused medial epiphyses, 12 clavicles from young adults denoted by partially fused medial epiphyses, 151 clavicles from adults having completely fused medial epiphyses, and 325 clavicle fragments with an unobservable epiphyseal fusion (one half or less of the medial epiphyses present). A total of 267 left clavicles and 286 right clavicles were analyzed. No significant association existed between side of the clavicle and age at death (Chi-square=1.066, df=3, p-value=0.785).

Table 4.1 Age Distribution of Poole-Rose Ossuary Clavicles by Side.

Age	Left *n* (%)	Right *n* (%)	Total
Subadult	33 (12)	32 (11)	65 (12)
Young adult	7 (3)	5 (2)	12 (2)
Adult	69 (26)	82 (29)	151 (27)
Unknown	158 (59)	167 (58)	325 (59)
Total	267 (48)	286 (52)	553

4.1 Minimum Number of Individuals

The morphological features of the clavicle used to estimate a minimum number of individuals (MNI) for the ossuary included the medial epiphysis, lateral epiphysis, and attachment site for the costoclavicular ligament. Clavicle fragments with less than half of the feature present were not included in the MNI estimation. The combined subadult, young adult, and adult clavicle distribution of observed presence of these features by side is presented in Table 4.2. The highest number was noted at 196 right lateral epiphyses, and the lowest was 109 left medial epiphyses. Therefore, based on the clavicle, 196 is the estimated MNI for the Poole-Rose ossuary.

Table 4.2 Observed Clavicle Morphologies by Side for MNI Estimation.

Morphology	Left	Right
Medial epiphysis	109	119
Lateral epiphysis	179	196
Costoclavicular impression	168	153

Previous studies of the Poole-Rose ossuary have provided a wide range of MNI estimates. The highest MNI estimate is 337 for the right petrous portion of the temporal bone of the skull (Seidemann, 1999). Baumer (2008) reported the lowest estimate of 49 using the transverse facet of the right first rib. The current MNI estimate of 196 using the clavicle fits in on the lower end of the total range of estimates, possibly owing to the small size of the bone allowing a greater amount of fragmentation.

Table 4.3 Previous Poole-Rose Ossuary MNI Estimates.

Reference	Feature	MNI
Seidemann, 1999	Right petrous portion of the skull	337
Schiess, 2002	Femoral zone two (adults) / lesser trochanter (subadults)	300
Lundin, 2000	Deltoid tuberosity of the humerus	249
Tague et al., 1998	Left ilium	242
Bodin, 2002	Left radial notch	221
Penney, 2005	Left talus	212
Parks, 2002	Left nutrient foramen of the radius	205
Dunne, 1999	Second cervical vertebra	204
Bordelon, 1997	Tibia	193
Smith, 1997	Supraorbital notch of the skull	166
Kelly, 2001	Metacarpal III	145
Baumer, 2008	Transverse facet of right rib 1	49

4.2 Degenerative Joint Disease

The distribution of observable DJD by joint surface and side of the clavicles appears in Table 4.4. A very significant association was noted between the presence of DJD and the joint affected (Chi-square=11.855, df=1, p-value=0.001). Joint degeneration was observed on the acromial articular surface of the clavicles more frequently than on the sternal articular surface. Slight degeneration (stage 1 severity) of the acromial end was observed at similar frequencies for both left and right clavicles, on 20 and 18 bones, respectively. On the sternal articular surface, slight DJD appeared on the left clavicles less often than the right, on six and 12 bones, respectively (see Figure 4.1).

Table 4.4 Degenerative Joint Disease (DJD) Distribution by Clavicle Joint and Side.

	Sternal articular surface		Acromial articular surface	
DJD severity	Left *n* (%)	Right *n* (%)	Left *n* (%)	Right *n* (%)
None present	85 (92)	98 (89)	68 (76)	81 (79)
Slight lipping/pitting	6 (7)	12 (11)	20 (23)	18 (18)
Moderate lipping/pitting	1 (1)	0 (0)	1 (1)	3 (3)
Total	92	110	89	102

Figure 4.1 Moderate Degenerative "Lipping" on the Sternal Articular Surface of a Typical Poole-Rose Ossuary Clavicle. Specimen Number 3-6-968-4. Photograph by Nicole E. Smith.

DJD of moderate severity was much less common, affecting only one left bone on the sternal end, and one left and three right bones on the acromial aspect. No significant association existed between the presence of DJD and the side of the clavicle (Chi-square=0.001, df=1, p-value=0.979).

4.3 Periosteal Reactions

Periosteal reactions on the Poole-Rose ossuary clavicles were not common. A very significant association existed between the presence of periosteal reactions and the healing stage of the reaction (Fisher's exact test, 1-sided, p-value=0.002). As shown in Table 4.5, the only cases of active periosteal reactions were seen on bones from two right and four left subadults (Figure 4.2). In these cases, the periosteal reactions are presumed to be related to normal

Table 4.5 Distribution of Periosteal Reactions.

Activity (age)	Left *n*/total (%)	Right *n*/total (%)
Active Reaction (subadult)	2/41 (5)	4/37 (11)
Healed Reaction (adult)	1/78 (1)	0/88 (0)
Healed Reaction (unknown)	4/147 (3)	0/157 (0)
Total affected	7	4

Figure 4.2 Periostitis of a Subadult Poole-Rose Ossuary Clavicle. Specimen Number 0-3-97. Photograph by Nicole E. Smith.

developmental processes of the bone. The other instances of clavicle periosteal reaction were inactive, or healed in activity level. These healed reactions appeared on one left clavicle from an adult and four left clavicles lacking the medial epiphysis for an age estimate. No significant association existed between the presence of a periosteal reaction and the side of the clavicle (Chi-square=1.024, df=1, p-value=0.312).

4.4 Lesions

A small number of clavicles in the ossuary exhibited lytic lesions on either the sternal or acromial articular surface (Figure 4.3). No significant association existed between the presence of lesions and the clavicular joint affected (Chi-square=1.343, df=1, p-value=0.247). The distribution of lesions was similar for both sides and both articular surfaces in clavicles from adults and clavicles of unknown age (Table 4.6).

Figure 4.3 Lesion on the Medial Epiphysis of a Typical Poole-Rose Ossuary Clavicle. Specimen Number 5-12-1043-3. Photograph by Nicole E. Smith.

No significant association was found between the presence of lesions and the side of the clavicle (Chi-square=0.003, df=1, p-value=0.956).The prevalence of lesions on clavicles with fused epiphyses was greater than that of clavicles without a medial epiphysis. No lesions were found on unfused clavicles. A significant association was seen between the presence of lesions on clavicles and the age at death (Chi-square=4.356, df=1, p-value=0.037). All of the bones that displayed lesions only had one lesion per bone.

Table 4.6 Distribution of Lytic Lesions.

	Sternal epiphysis		Acromial epiphysis	
Age	Left *n*/total (%)	Right *n*/total (%)	Left *n*/total (%)	Right *n*/total (%)
Adult	3/79 (4)	3/88 (1)	1/79 (<1)	4/88 (1)
Age unknown	1/147 (1)	0/157 (0)	4/147 (3)	3/157 (1)
Total affected	4	3	5	7

4.5 Healed Trauma

Evidence of healed trauma to the Poole-Rose ossuary clavicles was noted visually and radiographically (Figure 4.4). The prevalence of healed trauma was low in this sample, with only nine bones affected. Of those nine, six were healed midshaft fractures and three were healed fractures of the lateral third of the bone (Table 4.7).

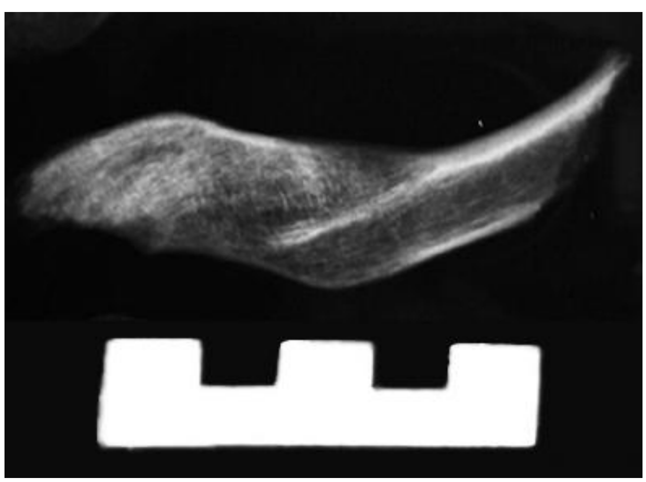

Figure 4.4 Radiographic Appearance of Healed Fracture to Midshaft of a Poole-Rose Ossuary Clavicle Fragment. Specimen Number 0-7-322. Photograph by Nicole E. Smith.

Table 4.7 Distribution of Healed Trauma.

Location	Left *n*/total (%)	Right *n*/total (%)
Midshaft	2/275 (1)	4/293 (1)
Lateral end	0/275 (0)	3/293 (1)
Total	2	7

Fractures of the right clavicle were more common than left fractures. No significant associations existed between presence of healed trauma and the side (Fisher's exact test, 1-sided p-value=0.105) or location on the clavicle (Fisher's exact test, 1-sided p-value=0.253).

4.6 Cut Marks

Cut marks on Poole-Rose ossuary clavicles were recorded according to appearance, frequency, and location on the shaft. Color of the bone was used to distinguish between the white cuts from trowel damage at excavation and the dark soil-stained cuts made prior to ossuary burial. Cut marks appeared on 47 left clavicles and 39 right clavicles out of the 553 bones analyzed (Figure 4.5). Of whole clavicles, cut marks appeared on ten left (four subadult, one young adult, and five adult) and six right (all adult) bones.

Figure 4.5 Cut Marks to Shaft of a Typical Poole-Rose Ossuary Clavicle. Specimen Number 3-10-1388-1. Photograph by Nicole E. Smith.

Most of the clavicles containing cut marks had less than 11 cuts per bone (Table 4.8). The maximum number of cuts per bone was 64 on a single clavicle. Cut mark presence was similar on both left and right clavicles, with slightly more left clavicles affected than right. No significant association existed between the presence of cut marks and the clavicle side (Chi-square=1.625, df=1, p-value=0.202) or age at death (Chi-square=2.775, df=2, p-value=0.250) (Table 4.9).

Table 4.8 Number of Cut Marks on Clavicle Per Side.

Cut marks per bone	Left *n* (%)	Right *n* (%)
1-10	23 (49)	17 (46)
11-20	8 (17)	8 (21)
21-30	2 (4)	5 (13)
31-40	5 (11)	4 (10)
41-50	5 (11)	1 (3)
51-60	2 (4)	3 (8)
61-70	2 (4)	0 (0)
Total	47 (18)	38 (13)

Table 4.9 Distribution of Clavicles with Cut Marks

Age	Left *n* (%)	Right *n* (%)	Total
Subadult	8 (24)	4 (13)	12(19)
Young adult	2 (29)	2 (40)	4 (33)
Adult	12 (17)	14 (17)	26 (17)
Unknown	25 (16)	18 (11)	43 (13)
Total	47 (18)	38 (13)	85

Cut marks were recorded based on location of their presence on the bone. The specific location of each cut mark was then associated with muscle and ligament attachment sites on the bone (Table 4.10). Most of the cut marks observed on the clavicles were associated with

Table 4.10 Cut Marks by Associated Muscle and Ligament Attachment Sites.

Attachment site	Left			Right			Total
	Adult *n* (%)	Juvenile *n* (%)	Unknown *n* (%)	Adult *n* (%)	Juvenile *n* (%)	Unknown *n* (%)	
Pectoralis major	9 (47)	5 (42)	11 (36)	11 (46)	3 (60)	4 (15)	43 (37)
Trapezius	5 (26)	2 (17)	7 (23)	3 (13)	0 (0)	11 (42)	28 (24)
Deltoideus	2 (11)	2 (17)	6 (19)	5 (21)	0 (0)	7 (27)	22 (19)
Subclavius	0 (0)	0 (0)	4 (13)	1 (4)	1 (20)	2 (8)	8 (7)
Trapezoid ligament	1 (5)	1 (8)	2 (7)	1 (4)	0 (0)	1 (4)	6 (5)
Sternocleidomastoid	1 (5)	1 (8)	0 (0)	2 (8)	0 (0)	0 (0)	4 (3)
Costoclavicular ligament	1 (5)	0 (0)	0 (0)	0 (0)	0 (0)	1 (4)	2 (2)
Acromioclavicular ligament	0 (0)	0 (0)	1 (3)	1 (4)	0 (0)	0 (0)	2 (2)
Sternohyoid	0 (0)	0 (0)	0 (0)	0 (0)	1 (20)	0 (0)	1 (1)
Conoid lig.	0 (0)	1 (8)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)
Total	19 (16)	12 (10)	31 (27)	24 (21)	5 (4)	26 (22)	117

attachments of the pectoralis major, trapezius, and deltoideus muscles. Cut marks tended to affect all age categories to similar degrees, with ranges from four to 27% of category samples affected.

4.7 Metric Analysis

Sixty clavicles were included in the metric analysis of adults. Metric dimensions of the clavicles followed a Gaussian distribution in general, with left clavicles tending to be longer and more robust than rights. However, the differences in the means of clavicle dimensions by side were not significant for any of the measurements. The means of all measurements were larger for left clavicles than right clavicles, except for maximum medial curvature (Table 4.11). All metric values fit a normal distribution (Lillie test, $p < 0.05$), except those of the right vertical diameter at midshaft and right maximum lateral curvature.

Table 4.11 Adult Metric Clavicle Analysis by Side.

	Left			Right		
	n	Mean	SD	*n*	Mean	SD
Maximum length	30	153.5	9.9	30	151.6	10.1
Sagittal diameter	30	11.0	1.3	30	10.9	1.2
Vertical diameter	30	10.5	1.1	30	10.1	1.2
Medial curvature	30	16.8	2.7	30	16.8	3.0
Lateral curvature	30	12.8	3.0	30	12.3	2.8

Associations between the clavicular measurements were determined by Pearson product-moment correlation coefficient (Table 4.12). Very significant associations were found between maximum length and sagittal diameter at midshaft for both left and right clavicles, between right maximum length and vertical diameter at midshaft, between right sagittal and vertical diameters at midshaft, and between left maximum medial and lateral curvatures. Other significant associations were noted for left clavicles between sagittal and vertical diameters at midshaft, vertical diameter at midshaft and maximum medial curvature, vertical diameter at midshaft and maximum lateral curvature, and maximum medial and lateral curvatures.

Table 4.12 Correlation of Clavicle Metric Values by Side.

		Max. length	Sagittal diameter	Vertical diameter	Medial curvature	Lateral curvature
Left (*n*=30)	Max. length	—				
	Sagittal diameter	.625**	—			
	Vertical diameter	.358	.408*	—		
	Medial curvature	.145	.285	.445*	—	
	Lateral curvature	.106	-.084	-.375*	-.549**	—
Right (*n*=30)	Max. length	—				
	Sagittal diameter	.605**	—			
	Vertical diameter	.588**	.612**	—		
	Medial curvature	.062	.253	.294	—	
	Lateral curvature	.255	.014	.117	-.291	—

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

4.8 Sex Estimation

Data from the metric analysis were entered into Fordisc 3.0 to suggest sex of the clavicles that could be measured with accuracy. The results from Fordisc assigned male sex to 48 clavicles and female sex to 44 clavicles (Table 4.13). This calculation of sex is likely to contain a degree of error from the differences in skeletal population of the Poole-Rose ossuary archaeological sample and the modern forensic sample upon which the Fordisc program is based. Another source of possible error arises from the differences of First Nation ancestry of the Poole-Rose ossuary and the white and black ancestry of the Fordisc skeletons.

Table 4.13 Fordisc Assessment of Sex.[1]

	Left *n* (%)	Right *n* (%)	Total
Male	29 (59)	19 (44)	48 (52)
Female	20 (41)	24 (56)	44 (48)
Total	49 (53)	43 (47)	92

[1]See above text for possible sources of error in clavicular sex assessment.

4.9 Rhomboid Fossae

The presence of rhomboid fossae in this sample was defined by a distinct depression that perforated the cortical bone of the costoclavicular ligament attachment site (Figure 4.6). Impressions of ambiguous degrees of depressed cortical bone were not included in the rhomboid fossa count. As shown in Table 4.14, clavicles from juveniles displayed rhomboid fossae more frequently than clavicles from adults. A very significant association existed between the presence of a rhomboid fossa and the age at death (Fisher's exact, 1-sided, p-value<0.001).

Figure 4.6 Rhomboid Fossa of a Typical Poole-Rose Ossuary Clavicle. Specimen Number 1-23-824. Photograph by Nicole E. Smith.

Both left and right clavicles contained a similar prevalence of rhomboid fossae, with this feature occurring slightly more often on left bones. Of the 29 left clavicles and 19 right clavicles denoted as from males by Fordisc, only one of each side contained rhomboid fossae (4% and 5%, respectively). Both of these clavicles belonged to young adult individuals, as evidenced by their partially-fused medial epiphyses.

Table 4.14 Rhomboid Fossa Prevalence by Side and Sex.

	Left *n* (%)	Right *n* (%)	Total
Young adult male	1 (4)	1 (5)	2 (14)
Juvenile	6 (18)	4 (13)	10 (71)
Adult (unsexed)	1 (2)	1 (1)	2 (14)
Total	8 (57)	6 (43)	14

Clavicles from juveniles had a higher frequency of rhomboid fossae, appearing on six of 33 left clavicles and 4 of 32 right clavicles (18% and 13%, respectively). Of the 69 left and 82 right fused clavicles in this sample, one of each side contained rhomboid fossae (two percent and one percent, respectively). No significant association existed between the presence of a rhomboid fossa and the side of the clavicle (Chi-square=0.335, df=1, p-value=0.563).

CHAPTER FIVE: DISCUSSION AND CONCLUSION

The findings of this study provide new information about the population represented by the Poole-Rose ossuary sample. Based on the clavicle, the ossuary contained at least 196 individuals of juvenile, young adult, and adult age categories. Although a specific age could not be given to any of the clavicles, the small size of several clavicles suggests the presence of infants in the ossuary. This finding supports the conjectures of previous studies that there is a distinction between the customs of the Poole-Rose ossuary population and those of the Huron as told by the Jesuits (McKillop and Jackson, 1991; Tooker, 1964).

Non-metric significant associations were noted between the prevalence of DJD in the acromioclavicular joint, the prevalence of active periosteal reactions, the prevalence of lesions in adult individuals, and the prevalence of a rhomboid fossa in subadult individuals. The occurrence of DJD in the shoulder joint more often than in the chest suggests a difference in usage of these two joints, but is not at all surprising as the shoulder has a greater range of motion than the chest. DJD affected the left and right clavicles to a similar degree, which may be explained by cultural subsistence activities involving the use of both arms.

A major component of the subsistence activities practiced by groups in eastern North America was the processing of dried maize by pounding with wooden mortar and pestles (Bridges, 1989; Engelbrecht, 2003). During this activity, practiced traditionally by females, the arms held the wooden pestle above the head and then brought it down forcibly to pound the maize in the mortar (Bridges, 1989). Such an activity would have involved not only the habitual use of both shoulder joints simultaneously, but also likely caused the shoulders to absorb the impact shock of the pounding action. Since the clavicle cannot be sexed accurately without other associated bones (such as the hip), a comparison between male and female DJD could not be made. However, male traditional activities would have included hunting with bow and arrow, which would have also involved the use of both arms to similar degrees (Bridges, 1989).

The greater frequency of active periosteal reactions as compared with healed reactions is an expected result as well. All of the active periosteal reactions in this population appeared on subadult individuals, who were likely to have less developed immune systems than those of the adults in the population. Goodman and Armelagos (1988) hypothesize that an inverse relationship exists between childhood stress and survivorship of the individual. Following their hypothesis, the active periosteal reactions noted on subadult Poole-Rose ossuary clavicles may have been a bony response to the physiological stresses that eventually led to the death of the individual.

The presence of lesions in adults more often than subadults may be explained by the same hypothesis of underdeveloped subadult immune systems. The clavicular lesions are consistent with the lesions characteristic of tuberculosis in the Poole-Rose ossuary vertebrae and ribs described by Dunne (1999) and Baumer (2008), respectively. Bone lesions caused by tuberculosis infections are estimated by Pfeiffer (1984) to affect only one to seven percent of cases—those of long duration, which are unlikely to appear on younger individuals. If subadults contract the disease, they will either die prior to developing a bony response, or if they survive the onset of the disease, they probably will not develop lesions until they are older. Additionally, the clavicle is rarely affected by skeletal tuberculosis (Ortner, 2003). Therefore, the appearance of several clavicle lesions in this ossuary sample may represent a substantial non-skeletal presence of tuberculosis in the population.

The findings of the present study supported the findings of Rogers et al. (2000) that the presence of rhomboid fossa is more common in younger individuals than in adults. The male sex correlation with presence of rhomboid fossa could not be accurately evaluated from the results of this study because of the small sample size of adult clavicles with these fossae. Most clavicles with rhomboid fossae were subadults and sex estimation was not attempted.

The presence of healed trauma in the Poole-Rose clavicle sample of about one percent per side is low. The Libben site in Ohio contained healed fractures in nearly six percent of whole clavicles in the sample (Lovejoy, 1981). As clavicle fractures are commonly associated with accidental injury resulting from falls, the low incidence of these fractures in the ossuary was not an expected result.

The clavicle cut marks analyzed in this study suggested a tendency for fewer than 10 cut marks per clavicle and for these cut marks to appear on attachment sites for the pectoralis major, trapezius, and deltoideus muscles. The general low number for cuts per clavicle is explained by the degradation of soft tissue after death and before burial for most ossuary individuals. Only a small percentage of the ossuary population would have died in the months preceding the creation of the Poole-Rose ossuary. The three common muscle attachment sites associated with clavicle cut marks are also the largest muscle attachment sites on the surface of the clavicle. Since larger attachment sites correspond to more muscle to remove from the bone, more cut marks are expected on these sites.

Significant metric results showed a strong correlation between length and sagittal diameter of the clavicle for both left and right bones, and between the two diameters to each other, which was correlated more strongly in right bones. This result shows a positive relationship between length and robusticity of the clavicle, especially in right bones. Additionally, the left clavicles showed a positive association of lateral and medial curvature with vertical diameter, and of the two curvatures with each other. One possible interpretation of this curvature association is that the right limb, in right-handed individuals, is exposed to more mechanical loading, which causes variation in the curvatures. Therefore, the difference between right and left curvature associations in this study could reflect a lateral bias in mechanical loading for this population. Since most of the specific activities preformed by prehistoric agriculturalists (i.e. processing maize, using bow and arrows, hauling up fish in nets) required the use of both limbs (Bridges, 1989), the nature of this right bias in mechanical loading is unknown. However, Mays et al. (1999) hypothesize clavicles of the dominant limb are more curved than the non-dominant limb. Though they could not confirm this hypothesis in their article, the differences in curvature variation of the current study could represent a general curvature trend in right-handed individuals. More curvature variation studies are needed to validate this conjecture.

The mean clavicular maximum lengths for left and right bones in the ossuary population were 153.5 ±9.9mm and 151.6 ±10.1mm, respectively. These lengths seem to be large in general when compared with the same measurement of clavicles from other populations (see table in Olivier, 1956:406). In her doctoral dissertation, Shirley (2009) calculated the maximum length of clavicles from the William F. McCormick Clavicle Collection; a collection of paired clavicles obtained from autopsies in East Tennessee between 1986 and 1998. She found an average length of 159.6 ±0.87mm for European American males, 142.6 ±0.87mm for European American females, 161.3 ±0.95mm for African American males, and 144.4 ±0.49mm for African American females. The lengths of Poole-Rose ossuary clavicles fit in between the average female and male lengths of Shirley's modern sample study. Assuming the ossuary contained equal amounts of males and females, this comparison suggests the individuals of the ossuary population may have had a similar general stature to modern European Americans and African Americans.

The goal of this study was to extract cultural information about the Poole-Rose ossuary population through the analysis of the clavicle. Analysis revealed few bones were affected by disease processes. Most of these changes were likely age- or activity-related. The small number of diseased clavicles agrees with previous studies of Poole-Rose ossuary bones, indicating that the population was healthy. An alternative interpretation, following Wood et al. (1992), suggests that the absence of skeletal manifestation of disease could denote an acute disease process affecting a more susceptible portion of the population. The only exception to the apparent healthy state of the Poole-Rose ossuary arises from the lesions found on some of the clavicles, as well as other bones in the ossuary. Although the prevalence of skeletal lesions is low, the lesions are attributed to tuberculosis, a disease that rarely affects the skeleton in clinical settings. The presence of skeletal lesions on various bones of the Poole-Rose ossuary may represent a larger degree of tuberculosis infection in the population than the proportion with skeletal manifestation of the disease.

The metric and non-metric evaluation of the clavicles in the Poole-Rose ossuary suggests a lack of side preference in the cultural activities of the population. Left and right clavicles tended to be affected to similar degrees by DJD and healed fractures. Measurements of the clavicles were similar for both sides. However, a side distinction exists in correlations of clavicle measurements within each bone. Right bones tended to be more variable in their curvatures than left bones, suggesting differential pressures from handedness that were generally placed on the right side more often than the left.

Although ossuary burials restrict analysis at the level of the individual, osteological analysis of ossuary bones by skeletal element allows the researcher to make assumptions about the health and culture of the population as a whole. Combined with previous research on Poole-Rose ossuary skeletal elements, this thesis adds another piece in the puzzle of culture reconstruction for the Late Woodland people buried in the Poole-Rose ossuary. Future analysis of unexplored ossuary bones will serve to complete the osteological profile for this population.

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VITA

Nicole Elizabeth Smith was born in Greensboro, North Carolina, in September, 1986. She was graduated from the University of North Carolina at Chapel Hill in May 2008, with a Bachelor of Arts in anthropology and a minor in archaeology. Nicole entered the master's program in anthropology in the Department of Geography and Anthropology at Louisiana State University in August 2008. She was awarded an assistantship by Ms. Mary Manhein to work in the FACES lab documenting pathologies in the forensic collection, which also funded her graduate studies at LSU. She was able to attend the American Academy of Forensic Sciences conferences in 2009 and 2010 thanks to sponsorship by Ms. Manhein. After graduation, Nicole plans to pursue a doctorate in anthropology and continue her research in paleopathology.