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An Analysis of Osteoarthritis of the Upper Limbs in the Tchefuncte Site (16ST1)

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AN ANALYSIS OF OSTEOARTHRITIS OF THE UPPER LIMBS IN THE
TCHFUNCTE SITE (16ST1)

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

Mallory Baldrige
B.S., New York University, 2007
August 2014

For the relatives.

And for Paul, who provided much comfort through this process.

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Abstract

Osteoarthritis is a degenerative disorder of the synovial joints which is frequently linked to activity and age, as well as numerous other etiologies. In particular, osteoarthritis of the shoulder is often shown to correlate with age, while osteoarthritis of the elbow is often shown to correlate with physical activity. The presence and pattern of osteoarthritis has been investigated in numerous Native American populations, but to date, its presence has not been investigated in the skeletal collection from the Tchefuncte site (16ST1), a Tchula Period shell midden site in St. Tammany Parish, Louisiana. Osteoarthritis of the upper limbs is examined in this population in order to assess patterns of activity as delineated by sex and age category, as well as to examine its co-morbidity with other pathologies (i.e., treponemal disease, cribra orbitalia, porotic hyperostosis, and dental pathologies).

Ultimately, the small size and poor preservation of the 16ST1 skeletal sample prevented decisive conclusions. Nonetheless, the bioarchaeological evidence suggests that the Tchefuncte population generally experienced low levels of physical stress. For osteoarthritis, no group, defined either by age, sex, or burden of disease, appears to have been more physically stressed than any other. The presence of a few stand-out instances of moderate to severe osteoarthritis can likely be attributed to the longevity of most of the people in the sample, although disease or trauma may have contributed in some cases to the development of osteoarthritis, particularly in the case of one young (20-30 years) individual.

Chapter One: Introduction

Osteoarthritis, a degenerative disorder of the synovial joints, is frequently cited as one of the more common pathologies in both past and present populations (Bridges 1992; Jurmain 1977; Snow 1945; Weiss and Jurmain 2007). Although the evidence is equivocal, many investigators (e.g., Bridges 1991, 1992; Jurmain 1977; Ortner 1968; Tainter 1980) have shown that physical activity and trauma can result in patterns of behavior-linked osteoarthritis. Numerous Native American populations have been examined for indications of osteoarthritis (e.g., Dabbs 2011; Jurmain 1990; Tainter 1980; Woo and Sciulli 2013) but, to date, its presence has not been investigated in the skeletal collection from the Tchefuncte site (16ST1).

As a research project for my master's thesis in anthropology, I examined the adult individuals of the Tchefuncte site skeletal collection for evidence of osteoarthritis in the upper limbs. This project expands on the paleopathological investigation of skeletal remains at the site begun by Snow (1945), and continued by my more recent predecessors at Louisiana State University, Lewis (1991; 1994; 1998) and Listi (2007; 2011; n.d). The goals of this project are to (1) examine the remains from the Tchefuncte site for patterns of osteoarthritis in the upper limb joints that may be defined by activity, age, or sex; (2) explore the connection, if any, between osteoarthritis and previous pathologies identified in the Tchefuncte population (e.g., treponematosi s, oral pathologies, and cranial porous lesions); and (3) contribute to the body of literature on the Tchefuncte culture, in which bioarchaeology has been largely neglected. By analyzing the collection for evidence of osteoarthritis of the upper limbs, my project contributes to our understanding of physical stress on the population of the Tchefuncte site of southeastern Louisiana, and to the wider scholarship on osteoarthritis in prehistoric North American Indians.

Chapter Two: Literature Cited

Archaeological Context

The Tchula period is the southeastern sub-category of the Early Woodland period, which began no earlier than 800 B.C. and ended in the first century B.C. (Hays and Weinstein n.d.; Jeter and Williams 1989; Kidder 2002), though exact dates are conflicting. Two archaeological cultures have been identified within the Tchula period: the Tchefuncte culture, and the Lake Cormorant culture (Kidder 2002). The Tchefuncte culture is further divided into inland and coastal variations (Jeter and Williams 1989). Within the coastal Tchefuncte culture, three regional phases in Louisiana are recognized by Jeter and Williams (1989): the Pontchartrain phase sites which are found near Lake Maurepas and Lake Pontchartrain, and near New Orleans; the Grand Lake phase which occurred between Louisiana's central coast northward and the Mermentau and Vermilion rivers; and the Sabine Lake phase, which covers areas in far southwestern Louisiana and southeastern Texas. This thesis focuses on a single site in the coastal Tchefuncte culture and the Pontchartrain phase, the Tchefuncte site (16ST1).

Archaeological sites associated with the Tchula period are generally simple in comparison to the preceding Archaic period Poverty Point site, and have no evidence of long-distance trade, social stratification, or specialized economy (Kidder 2002). These generalizations hold true for both the Tchefuncte culture in general and the specific Tchefuncte site. Coastal Tchefuncte sites within the Pontchartrain phase may be identified as either seasonal-occupation hunting camps or villages that were occupied year-round (Jeter and Williams 1989). Shenkel (1984a) proposed that seasonal hunting camps can be distinguished from year-round occupations by differences in site formation processes and artifact and faunal assemblage. Sites thought to be

hunting or fishing camps are characterized by small earthen mounds, high artifact densities, postholes, and small, plain ceramics, while year-round occupations are usually identified by large shell middens, low artifact densities, lack of postholes, and large, decorated ceramics (Shenkel 1984a). The Tchefuncte site is thought to have been occupied year-round, as it is formed by two shell middens without postholes, marked by the presence of decorated pottery, and contains remains from a wide array of fauna (Hays and Weinstein 2010).

Sibley, Jr., (1967, 133) referred to the Tchefuncte culture as “a coastal adaptation of the Archaic Culture,” but evidence of flooding, climate change, and distinct social differences have led some archaeologists to argue in favor of a cultural discontinuity (Kidder 2002, 2006; Hays and Weinstein 2010). Kidder (2006) proposes that the marked differences between the preceding Poverty Point culture and the Tchefuncte culture can be attributed to a period of climate change in the region. These climate changes resulted in the abandonment of Poverty Point and a cultural hiatus in the Lower Mississippi Valley until the advent of the Tchefuncte culture (Kidder 2006).

The Tchula period is considered an important phase of acclimatization to the coastal setting (Gibson 1975). Jeter and Williams, Jr., (1989) recommend the division of the Tchefuncte culture into Inland Tchefuncte and Coastal Tchefuncte, of which 16ST1 falls into the coastal category. This division was first suggested by Ford and Quimby (1945), though they believed the known Tchefuncte culture sites could be placed in three categories: Copell Island, coastal shell mound sites (Little Woods, Tchefuncte site, and Big Oak Island), and inland mound sites (Lake Louis and Lafayette). Ford and Quimby (1945) considered these sites connected by culture and general time period. Though they seriated the sites into earliest, middle, and latest occupation, they considered that differences between sites to be environmental, not temporal.

Additionally, Jeter and Williams, Jr., (1989) support Gagliano's (1967b) and Phillips' (1970) placement of the Tchefuncte site's occupation into the Pontchartrain phase of the Tchefuncte culture. As described by archaeologists, the Pontchartrain phase is defined by shell midden sites, poorly tempered or un-tempered ceramics, and location near Lake Maurepas or Lake Pontchartrain (Jeter and Williams, Jr. 1989). All of these characteristics are found in the Tchefuncte site.

Ford and Quimby's (1945) overview of the Tchefuncte culture discusses several sites in southeastern Louisiana, including the Tchefuncte site (16ST1), which today is located in Fontainebleau State Park in St. Tammany Parish. The occupants of 16ST1 built the two shell middens which form the site, named Midden A and Midden B by Ford and Quimby (1945). Both middens are composed mainly of the shells of *Rangia cuneata*, or brackish-water clams, which were harvested in great number by the site's inhabitants. At the time of their investigation, Ford and Quimby (1945) considered Tchefuncte to be the oldest culture in the Lower Mississippi Valley.

The Tchefuncte site, the type site for the Tchefuncte culture, came to the attention of the Civilian Conservation Corps in 1938 when the mounds were being considered as a source of shell for construction purposes (Ford and Quimby 1945). Before mining the mounds for shell, Clarence L. Johnson, a historian with the Civilian Conservation Corps, led an archaeological excavation of Midden B, the west midden, although only half of that midden remained after earlier commercial dredging (Ford and Quimby 1945). At the time of Johnson's excavation, Midden B had a long oval shape approximately 150 feet long and 100 feet wide, set on a northeast-southwest orientation (Ford and Quimby 1945). Johnson's crew excavated 53 five-foot squares on the midden, 36 of them to the water level, and all but two without set

stratification (Ford and Quimby 1945). The excavators could not discern floors or occupation levels, although pockets of clean shell were found and proposed to be processing stations (Ford and Quimby 1945).

In 1941, Edwin B. Doran, Jr., of the Louisiana Archaeological Survey, directed further excavations at the Tchefuncte site; his crew of 35 conducted excavations on Midden A and completely excavated Midden B (Ford and Quimby 1945). At the time of this excavation, Midden A was approximately 250 feet long and 100 feet wide, oriented in the same direction as Midden B (Ford and Quimby 1945). In accordance with some of the techniques used by Johnson, Doran's crew excavated Middens A and B in five-foot squares and six-inch increments (Ford and Quimby 1945). Often, excavations extended below the water table (Ford and Quimby 1945). Both middens were found to have been formed upon a sandy incline, which in turn sits atop the clay Prairie Terrace formation (Ford and Quimby 1945). Midden B was completely excavated and no longer exists today (Ford and Quimby 1945; Hays 2000). Site records from the National Park Service indicate that Midden A has changed dimensions since Doran's investigation, today measuring approximately 170 feet long and 49 feet in width (Hays 2000).

The Tchefuncte site was occupied from approximately 400 BC until approximately AD 1, as dated by radiometric assays (Hays and Weinstein n.d.), although other Tchefuncte culture sites date as early as 800 BC (Hays and Weinstein 2010). The excavations of Middens A and B recovered more than 48,000 ceramic sherds from the Tchula period, 43 human burials, and an assortment of clay pipe fragments, chipped and ground stone tools, and objects made of bone and shell (Ford and Quimby 1945; Neuman 1984). The bone, clay, and shell objects listed by Ford and Quimby (1945) included: Poverty Point clay objects, clay pipe fragments; blades, scrapers, and projectile points made from chipped stone; weights, plummets, saws, and metates made from

ground stone; worked and unworked animal bone and antler; and gouges made of shell. Ford and Quimby (1945, 67) noted that Tchefuncte pottery was often coiled during production, but “poorly welded,” prone to breaking, and “marked by lack of care or skill.”

Tchefuncte culture sites have produced numerous zooarchaeological remains that have provided information regarding subsistence strategies (Hays and Weinstein 2010; Jeter and Williams, Jr. 1989; Neuman 1984). Evidence shows that the Tchefuncte populations lived on top of the site middens in egalitarian bands of hunter-fisher-gatherers (Sibley 1967). At the Tchefuncte site, occupants made use of nearby water sources for subsistence, the site being located within a marsh area and only a half-mile from the shores of Lake Pontchartrain (Ford and Quimby 1945). The assemblage of faunal remains suggests that the population living at the Tchefuncte site hunted year round, indicating a sedentary lifestyle (Hays and Weinstein 2010). Reliance on aquatic resources is evidenced by remains of fresh- and brackish-water animals, including alligator gar, turtle, catfish, oysters, and black drum (Lewis 1991). Faunal remains also include white-tailed deer as a primary food source, and a number of other vertebrates, including rabbit, turkey, goose, and duck (Lewis 1991).

In addition to the zooarchaeological remains, Hays and Weinstein (2010) consider the abundance of ceramic artifacts recovered from the Tchefuncte site, which is further evidence of long-term occupation of the middens and the sedentary lifestyle of the site’s population. The ceramic assemblage of the Tchefuncte culture has been of particular interest to archaeologists and ceramicists for its unique appearance due to the “crude” construction and lack of temper in the clay (Hays and Weinstein 2010, 98). Hays and Weinstein (2010, 104) note that most Tchefuncte culture sites, including 16ST1, contain very few exotic items which might have been

obtained through trade, suggesting that the inhabitants “lived in relatively autonomous and isolated communities.”

Bioarchaeology of the Tchefuncte

Some discrepancy exists between reports regarding the number of individuals excavated from the Tchefuncte site. Lewis (1991, 1994, 1998) counts 58 individuals excavated from 51 interments in the two middens, eight of which are indicated as two-person burials. Ford and Quimby (1945), however, only reported 43 burials from Midden A, 21 of which were in the flexed position, 22 of which were bundled, and none of which contained grave goods. Additionally, Ford and Quimby (1945) note the presence of Midden B burials in a summary, but do not refer to these burials in any other discussion. Possibly, Lewis (1991, 1994, 1998) counted an unknown number of Midden B burials toward the total number in her studies, and fragmentation and commingling of the remains may today obscure the exact number of individuals represented by the recovered remains. It is clear, however, that some of the interred individuals had their legs broken at the time of burial (Ford and Quimby 1945), which Lewis (1991) speculates may be the only archaeological indication of ritual burial practice at the Tchefuncte site.

Included in Ford and Quimby’s monograph is a discussion of palaeopathology of the Tchefuncte population by Charles Snow (1945, 99). Snow examined seven individuals from 16ST1, along with 13 individuals from other Tchefuncte culture sites (Little Woods and the Lafayette Mound site), all of which are compared to measurements of the remains found at a Tchefuncte site at the Copell place in Vermilion Parish, Louisiana (Snow 1945). In Snow’s analysis of the skeletal sample, cranial morphology, stature estimates, cribra orbitalia,

osteoporosis, and dental pathologies are discussed (Snow 1945). Cranial morphology is utilized by Snow (1945, 100) to determine that the remains from the Tchefuncte culture sites are likely of the same “physical group” as the remains from the Copell site. Snow’s (1945) observations of the postcranial remains suggest that the males of the Tchefuncte culture sites were of medium stature, and Snow notes the presence of squatting facets which indicate that the sites’ inhabitants habitually squatted on the ground. Additionally, the presence of porotic hyperostosis and cribra orbitalia are noted (Snow 1945). Snow (1945) suggested that porotic hyperostosis is attributed to nutritional deficiencies, while cribra orbitalia is suggested as a symptom of osteoporosis. Today, parasitic infection and nutritional deficiencies are typically thought to cause porotic hyperostosis and cribra orbitalia (Roberts and Manchester 2005). Osteoarthritis is assumed because it “has been the most commonly named disease in many reports on American skeletal material,” but is not investigated (Snow 1945, 107).

Since Snow’s initial investigation, only a small number of other projects have examined the skeletal collection from the Tchefuncte site. Lewis has produced several papers analyzing the collection for treponemal diseases (1991; 1994) and juvenile rheumatoid arthritis (1998). Lewis’ (1991) master’s thesis was an analysis of the pathologies present in the population of the Tchefuncte site. Her examination necessitated the reconstruction of many skeletal elements, determination of sex and age, and the identification of faunal elements that had been intermingled with the human skeletal remains from the site (Lewis 1991). The use of histology, macroscopic examination, and radiography facilitated a diagnosis of a chronic infection caused by *Treponema pallidum*, which manifests as yaws and endemic (non-venereal) syphilis. She noted the presence of osteoarthritis, but did not investigate it. Of the 58 individuals examined by Lewis (1991), 75.8% ($n = 44$) exhibit at least one diseased element, but the overall longevity of

the site's inhabitants (two-thirds of whom were aged 40 years or older at time of death; Lewis 1994) suggests that treponematosi s was not the cause of death in most cases.

The interplay of treponematosi s and Lyme disease was considered by Lewis (1994) as an explanation for the slight expression of treponemal disease in the 16ST1 inhabitants compared to the expected expression in a population experiencing chronic, systemic disease. *Treponema pallidum* and *Borrelia burgdorferi* are related spirochetes which cause endemic syphilis and Lyme disease, respectively (Lewis 1994). Zooarchaeological evidence of reliance on white-tailed deer as a food source suggests the likelihood that the population of 16ST1 were exposed to *Borrelia burgdorferi* through contact with *Borrelia*-carrying ticks, which feed on deer and humans (Lewis 1994). The presence of *Borrelia burgdorferi* may provide partial immunity to closely-related *Treponema* spirochetes, contributing to the longevity of many individuals from the site who likely contracted endemic syphilis or yaws in childhood (Lewis 1994).

Lewis (1994, 1998) also investigated a single possible case of juvenile rheumatoid arthritis from the Tchefuncte site. One subadult, aged approximately 18 years using epiphyseal fusion and the presence of an erupted third molar, was found buried with a second individual, a female aged 40 years or older using tooth wear and cranial sutures (Lewis 1998). The juvenile is described as “small,” “gracile,” and marked by lack of muscular development and unusual limb orientation which suggest disability (Lewis 1998, 231). On the other hand, the older individual is described as “large,” with “unusually well-developed muscle attachment sites compared to other females in this population,” which Lewis (1998, 231-7) speculates may be due to a long-term role as caregiver to the disabled juvenile. Lewis (1998) also draws on information regarding arthritis caused by Lyme disease (Lyme arthritis), which has clinical similarities to juvenile rheumatoid arthritis. The similarity between Lyme arthritis and juvenile rheumatoid

arthritis lead Lewis (1998) to conclude that either pathology may be present in the juvenile from 16ST1, and that a differential diagnosis may become possible with further study of Lyme disease.

Listi (2007, 2011, n.d.) examined 41 individuals in the Tchefuncte collection as part of a larger study examining the dietary transition from hunting-gathering to maize agriculture in the southern Lower Mississippi Valley (SLMV) during the Coles Creek Period (AD 700-1200). She examined multiple oral pathologies (including dental caries, calculus, antemortem tooth loss (AMTL), periodontal disease, abscesses, and tooth macrowear) as well as “nonspecific” pathologies including cranial porous lesions (in the vault and eye orbits), enamel hypoplasias in the canines, and Harris lines in the tibiae. Data from the Tchefuncte site were compared to other contemporaneous and slightly later populations (i.e., Pre-Coles Creek sites whose occupation dates ranged from 800 BC to AD 700), which included remains from the Lafayette Mounds, Little Woods, and Mount Nebo sites. Frequencies of each pathological condition were reported per individual (i.e., “individual count” or IC) as well as by tooth type (i.e., “tooth count” or TC) for the dental data (Listi 2011; n.d.).

Results showed that remains from 16ST1 exhibit a 20% incidence of dental caries when calculated by number of individuals, though that number drops to 4.2% when calculated by tooth count; the average number of caries per individual is 0.33 (Listi 2011). These numbers are moderate-to-high compared to other populations in the Pre-Coles Creek sample. Additionally, the Tchefuncte collection had the greatest prevalence of abscesses (41.4% by IC, 13% by TC) and incidence of calculus (90.3% by IC, 79.2% by TC) among the Pre-Coles Creek populations, though the remains exhibited some of the lowest incidences of antemortem tooth loss (22% and 4.9% for IC and TC, respectively) and periodontal disease (82.4% and 67.9% for IC and TC,

respectively). The wear score for Tchefuncte was 30, which indicates relatively heavy macrowear in the first molars (Listi 2011). For the nonspecific pathologies, 80% (IC) and 82.4% (TC) of the Tchefuncte sample exhibited enamel hypoplasias, which are among the higher frequencies in the Pre-Coles Creek sample (Listi, n.d.). Cranial porous lesions were found in 70% of the occipitals, 80% of the parietals, and 13% of the eye orbits; these numbers were on the low to moderate end of the range for the Pre-Coles Creek populations. Lastly, 11.1% of the Tchefuncte exhibited Harris lines in the tibiae, with an average of 0.22 lines per individual. These values are in the low range of frequencies for the Pre-Coles Creek populations (Listi, n.d.).

Ultimately, the data from the Tchefuncte site fell in the middle to higher range of pathological incidence for the Pre-Coles Creek samples, with the exception of Harris lines, abscesses, AMTL, and porous lesions in the eye orbits. It is also notable, however, that the Tchefuncte collection had the highest number of individuals and teeth available for study, a fact which may have affected the observed incidences of these pathologies. With regard to dietary transition, Listi's analysis reveals that the collections exhibited only a slight increase in oral pathologies through time; thus, the bioarchaeological evidence did not indicate a dietary transition had occurred during the Coles Creek period. Also, the relatively heavy dental pathology load for the Tchefuncte and other Pre-Coles Creek populations suggests a diet heavy in carbohydrates, which most likely included a variety starchy plants native to the region (e.g., amaranths, chenopods, goosefoot, little barley, maygrass and knotweed) (Listi 2007, 2011, n.d.).

The aforementioned studies represent the sum of all bioarchaeological data on the inhabitants of the Tchefuncte site. Rose and Harmon (1999, 66) assert that the "Tchula period is bioarchaeologically unknown," and note the dearth of information regarding physical stresses in Tchefuncte populations. Since the publication of that report, very few investigations have sought

to fill the vacuum of information. This thesis will contribute to the body of bioarchaeological knowledge on the Coastal Tchefuncte through an investigation of osteoarthritis of the upper limbs.

Osteoarthritis and Lifestyle

Osteoarthritis is an inflammatory condition also known as degenerative joint disease (DJD) (Bridges 1992; Weiss and Jurmain 2007). Osteoarthritis is caused by the degradation of cartilage at the synovial joints, and is often a normal part of the aging process, though severity may vary on the basis of sex, weight, population, climate, or physical activity (Bridges 1992; Larsen 1999; Ubelaker 1999; Weiss and Jurmain 2007). Symptoms of osteoarthritis are well-documented and “universal” (Larsen 1999, 165) and include the formation of osteophytes (frequently called “lipping”), pitting of the bone, and eburnation (Bridges 1992; Ubelaker 1999). Eburnation describes burnished, smooth areas of bone formed when the cartilage of a joint is damaged and bone directly contacts bone (Bridges 1992). The symptoms of osteoarthritis most frequently appear in the knee, hip, hand, shoulder, and vertebral joints, with the knee and shoulder most correlated with aging, but osteoarthritis can form in any moving joint (Bridges 1992; Jurmain 1980; Rogers *et al.* 2004).

Despite numerous studies on osteoarthritis, the skeletal markers of osteoarthritis and the role of activity in the development of degenerative joint disorders have long been the subject of disagreement among biological anthropologists. Ortner’s (1968) discussion of osteoarthritis at the elbow listed porosity as one of the possible markers of degenerative change to bone. Additionally, Ortner (1968, 139) asserts that activity-induced stress is the “most important factor” in degeneration of the elbow joint, as the elbow is a non-weight-bearing joint. The

appearance of osteoarthritis at the elbow is often indicative of repetitive stress or trauma (Bridges 1992; Ortner 1968), though other joints may develop osteoarthritis due to other factors. Of the upper limb joints, osteoarthritis in the elbow is the least correlated with age, but is highly correlated with use, especially in hunter-gatherer populations (Bridges 1992; Ortner 1968).

However, not all anthropologists accept porosity, osteophyte formation, or eburnation as markers for osteoarthritis. Rothschild (1997, 532) contends that porosity of the bone “should be deleted as an identifier for osteoarthritis,” citing his own study on the knees of 400 skeletons from the Hamman-Todd collection. Using osteophyte formation as the criteria for diagnosing osteoarthritis, Rothschild (1997) found porosity and osteoarthritis coinciding in only 5% of the sample. He also emphasized that clinical literature on osteoarthritis does not recognize porosity as a symptom (Rothschild 1997). Rather, Rothschild (1997, 532) suggests that porosity is a “macroscopic curiosity” which bears no relation to osteological pathology, and argues that eburnation is merely an indicator of severity, not a determining factor in the diagnosis of osteoarthritis.

In contrast, Weiss and Jurmain (2007) do consider eburnation a clear indicator of osteoarthritis, though they call into question the accuracy of using either osteophyte development or porosity as indicators of osteoarthritis. Instead, the authors note that formation of osteophytes is strongly correlated with aging, and may not be useful in making a diagnosis of osteoarthritis (Weiss and Jurmain 2007). Weiss and Jurmain’s (2007) review of more recent studies in osteoarthritis covers etiology in particular, citing studies in genetics, anatomical variation, body mass index, and mechanical influences on at-risk groups, and highlighting the need for a comprehensive study of the disease itself.

The role of activity in the etiology of osteoarthritis is also a debated topic. Jurmain's (1980) investigation of 798 skeletal remains sought patterns of osteoarthritis between four major appendicular joints: the shoulder, elbow, hip, and knee. The remains studied came from four populations, two of which were modern and two of which were archaeological: the Pecos Pueblo collection and an Alaskan Eskimo collection. Jurmain (1980) noted that the shoulder and hip joints were most affected by age, while the knee and shoulder more often developed osteoarthritis due to functional stress. Investigation of bilateral involvement of the joints revealed that the elbow stood out as the least symmetrical joint, which Jurmain (1980) interpreted as evidence of activity in the etiology of osteoarthritis. Additionally, Jurmain (1980) found that the two prehistoric groups exhibited a relatively greater occurrence of osteoarthritis at the elbow as compared to the modern groups, a possible indicator of the role of activity in etiology. He concluded that functional stress leads to the development of severe osteoarthritis, but also noted that age, duration, and intensity of stressors, as well as other factors, can affect degeneration at the joint (Jurmain 1980).

A decade later, Jurmain (1990) analyzed the remains of California Indians who lived as hunter-gatherers near what is now San Francisco Bay. The collection of 77 female and 90 male adults were examined for the presence of osteoarthritis at the shoulder, elbow, hip, and knee. The knee was the most frequently affected major joint, with 8.7% of the sample exhibiting moderate to severe osteoarthritis on the right side, and 6.5% on the left side. The elbow was the next most affected major joint, for which left and right sides were each affected in 5% of the sample population. The shoulder and hip were the least affected major appendicular joints, though Jurmain (1990) provided rates of involvement for the shoulder, which was affected on the right side in 4% of the sample, and on the left side in 2% of the sample. Jurmain (1990) also

compared the California Indian sample to the Pecos Pueblo and Alaskan Eskimo samples he previously studied (Jurmain 1980). This comparison demonstrated that the Alaskan Eskimo population was most severely and most frequently affected by osteoarthritis and from an earlier age, while the Californian Indian sample differed from Pecos Pueblo only in the greater incidence of osteoarthritis at the knee and elbow. Jurmain (1990) refused to speculate on any particular activities which may have influenced these patterns of osteoarthritis, though he suggested that osteoarthritic lesions are formed due to both age and activity.

Bridges (1991) compared the occurrence and severity of osteoarthritis between a group of Archaic hunter-gatherers and a group Mississippian agriculturalists, both from northwestern Alabama. Skeletal remains were examined for osteoarthritis at the major appendicular joints, the shoulder, elbow, hip, and knee. Her examination found that the groups exhibited similar patterns of degenerative joint disease, though the Archaic hunter-gatherers generally had higher frequencies of moderate or severe osteoarthritis. These differences were not always statistically significant. Along divisions of sex, Bridges (1991) found that the Archaic group did not differ significantly by sex, but that among the Mississippian agriculturalists, males exhibited higher frequencies of osteoarthritis than did the females. These differences may indicate the more egalitarian nature of the Archaic hunter-gatherers (Bridges 1991).

Tainter (1980) also utilized osteoarthritis to infer social differences in a Middle Woodland population from the Illinois Valley. Eighteen surfaces of the shoulder, elbow, hip, and knee were examined for presence of osteoarthritis, then ranked to determine if the population was socially stratified. After controlling for age, Tainter (1980) divided remains into social “levels” determined by the severity and occurrence of osteoarthritis. His results showed that the Middle Woodland population did have a group of individuals who may have been socially

ranked higher, based on their lower frequencies of osteoarthritis. The differences in osteoarthritis between the groups may be attributed to more adequate access to nutrition and less frequent participation in physical community tasks in the higher ranked group (Tainter 1980). The correlation found by Tainter (1980), however, assumes that higher ranked social groups participated in less physical labor. It may be the case that the Middle Woodland population revered physical labor, which would reverse Tainter's findings.

Woo and Sciulli (2013) hypothesized that social status could be determined by comparing the grave goods of Terminal Late Archaic Period hunter-gatherers from three sites in Ohio to the degree of osteoarthritis they exhibited. They hypothesized that higher frequencies of osteoarthritis were likely to designate persons of lower status, who would have had to take on greater amounts of physical labor in the community (Woo and Sciulli 2013). The remains were macroscopically analyzed for presence and severity of osteoarthritis, and the results compared to the quality and quantity of grave goods and placement of the grave of each individual. The authors found no statistically significant correlations between presence or quality of grave goods and degree of osteoarthritis, and instead found that grave goods were more associated with age and sex (Woo and Sciulli 2013).

Although there is some disagreement as to the role of physical activity in the development of osteoarthritis, many studies have shown a correlation between repetitive motions at certain joints and the severity of osteoarthritis at those joints (Bridges 1991, 1992; Larsen 1999; Ubelaker 1999). A number of researchers, some outside the field of anthropology, have focused on these other etiologies (see Weiss and Jurmain 2007), such as Oliveria *et al.* (1999) and Plomp *et al.* (2013). Oliveria *et al.* (1999) found that body weight and body mass index are positively correlated with the incidence of osteoarthritis at the hand, hip, and knee. Plomp *et al.*

(2013) explored the relationship between knee shape and development of osteoarthritis. These researchers showed that morphological factors played a role in osteoarthritis of the knee only (Plomp *et al.* 2013). They further noted that osteoarthritis at the hip was likely due to systemic factors, while osteoarthritis at the shoulder and elbow could not be quantified (Plomp *et al.* 2013).

Activity-based interpretation of osteoarthritis remains a common topic for bioarchaeological study despite these cautions. Patterns of osteoarthritic development within individuals and populations are used to speculate on social stratification (Tainter 1980; Woo and Sciulli 2013), occupation (Lai and Lovell 1992; Lovell and Dublenko 1999), overall health (Dabbs 2011), and imperialist oppression (Schrader 2012). The studies by Lai and Lovell (1992) and Lovell and Dublenko (1999) focused on the same group of four adults associated with the fur trade in 19th century Canada. For the three males studied, Lai and Lovell (1992) attributed the presence of osteoarthritis at the shoulder and elbow to frequent activities known to have been common in the fur trade. These males likely spent much time carrying and lifting trade items, as well as paddling or rowing along trade routes (Lai and Lovell 1992). Lovell and Dublenko (1999) returned to the skeletal sample, reaching the same conclusions regarding male activities as Lai and Lovell (1992), and expanding the scope of their research to include the one female skeleton in the sample. Although they chose not to attribute osteoarthritis to any one activity, the researchers found that the pattern of degenerative joint disorder exhibited by the female skeleton reflected the pattern expected of a woman engaged in strenuous household tasks for the time (Lovell and Dublenko 1999).

Dabbs' (2011) investigation of the overall health profile of Alaskan Eskimos included a study of osteoarthritis as a means of examining health changes between different time periods.

Dabbs (2011) assessed the profiles of two cultural groups from the region, the Ipiutak who lived in the area from 100 BCE to 500 CE, and the Tigara who lived in the area from 1200 to 1700 CE. Differences in health based on climatic and economic changes were investigated, as the Ipiutak mostly hunted caribou on land, while the Tigara were mainly involved in marine subsistence activities (Dabbs 2011). Although the overall health profiles of these groups were very similar, the Ipiutak exhibited higher degrees of osteoarthritis, which Dabbs (2011) attributed to the greater number of small traumas hunters experience falling and tripping over uneven terrain.

Schrader's (2012) study of osteoarthritis at Tombos in New Kingdom, Nubia, sought to understand the lifeways of Nubians under Egyptian imperial rule. As Tombos is in a politicized region at the border between Nubia and Egypt, it was unknown if the inhabitants would have been forced into greater physical labor, or if the Nubians and Egyptians peacefully coexisted there (Schrader 2012). The occurrence of osteoarthritis was very low at Tombos, especially when compared to other skeletal collections from the Nile Valley (Schrader 2012). The low incidence of osteoarthritis suggests that Tombos was a relatively less stressed environment and may even have served as an administrative center for Egyptian rule (Schrader 2012).

Evidence of osteoarthritis of the wrist is difficult to report due to the small size of many of the involved bones, which can often be overlooked or lost (Bridges 1992). Nonetheless, osteoarthritis of the wrist has been investigated in some studies. Jurmain (1990) reports that the greatest degenerative involvement of the peripheral skeleton among the remains from the site CA-ALA-329 are found in the hands, wrist, feet, and ankles. Thirty-one percent of the adults at the site are diagnosed with osteoarthritis in the wrist and hand, with both sexes fairly equally affected (Jurmain 1990). Before the age of 40 years, males are slightly more affected, while

females have more involvement of the wrist after 40 years (Jurmain 1990). In the 41+ years age category, Jurmain (1990) reports that 56% of males and 64% of females in the population are affected by osteoarthritis of the wrist. Jurmain (1990) attributes the high frequency of this pathology to recurrent micro-trauma at the joint. Additionally, approximately half of the affected population at CA-ALA-329 exhibits bilateral osteoarthritis; the unilateral cases are skewed very strongly toward the right wrist, with 71% of unilateral osteoarthritis affecting the right side (Jurmain 1990).

Molnar *et al.* (2011) investigate the occurrence of osteoarthritis in two hunter-fisher-gatherer groups from Sweden, using eburnation as the indicator of osteoarthritis. In these populations, the researchers report that 39% of observed eburnation was found in the joints of the wrist and hand, which they attribute to the large number of articular surfaces involved (Molnar *et al.* 2011). Presence of eburnation and age were positively correlated in the skeletal sample, and both hunter-gatherer groups exhibited higher frequencies of eburnation in the left wrist and hand, though the pattern was only true of the males at Västerbjers (Molnar *et al.* 2011). Molnar *et al.* (2011) ultimately conclude that the patterns of osteoarthritis in the sample are not correlated with activity patterns, and suggest that the etiology of osteoarthritis is complicated by numerous factors.

The investigation of a single Romano-British male by Roberts *et al.* (2006) examines the individual for degeneration of the wrist joint, specifically scapholunate advanced collapse (SLAC), which is commonly found in modern, clinical settings. SLAC is the gradual degeneration of the radioscaphoid and capitolunate joints, and is often attributed to trauma (Roberts *et al.* 2006). Rarely is SLAC found in the archaeological record, with only one report prior to publication by Roberts *et al.* (2006), possibly due to the difficulty of recovering carpal

bones. As SLAC is a pathology associated with DJD, its investigation uses the same macroscopic method as other cases of osteoarthritis, the observation of eburnation on articular surfaces (Roberts *et al.* 2006). The researcher chose to utilize eburnation as the only indicator of degeneration due to the disagreement among researchers of the usefulness of other indicators, such as pitting and formation of osteophytes (Roberts *et al.* 2006). The left and right distal radii also were involved in the degeneration of the wrist, having developed pitting and eburnation (Roberts *et al.* 2006). Clinical investigation of SLAC attributes its development to traumatic injury, such as a fall, though SLAC may develop as a secondary effect of arthritis or other inflammatory pathology (Roberts *et al.* 2006).

The upper limbs are an excellent resource for studying osteoarthritis in archaeological populations. Osteoarthritis formation at the shoulder is frequently correlated with chronological age (Bridges 1992; Jurmain 1980). The prevalence and severity of osteoarthritis have been shown to vary considerably between males and females, different social classes, rural and urban dwellers, and by age (Bridges 1991, 1992; Larsen 1999), and may be affected by other factors listed above. As the upper limbs have sites of both age-related osteoarthritis and activity-related osteoarthritis, the joints of the upper limbs have been selected for this project. Studies which examine patterns of osteoarthritis in Native American populations may contribute to a greater understanding of stress differences related to daily activities within and between populations.

Rose and Harmon (1999) noted that the Tchula period has not been the subject of much bioarchaeology, specifically stating the need for a study of osteoarthritis for the Lower Mississippi Valley and Tchula period. Similarly, while a great number of osteoarthritis studies on Native American populations focus on the transition from hunting-and-gathering to agricultural subsistence strategies (see Larsen 1995 for overview). Weiss and Jurmain (2007)

remark on the decline of osteoarthritis-focused analyses in the past two decades. The current study will help address this gap in the literature for the Southeast.

Chapter Three: Materials and Methods

Materials

For this research on the prevalence and severity of osteoarthritis in the individuals of the Tchefuncte site, the author performed macroscopic analysis of the 16ST1 skeletal collection, which is currently housed in the Museum of Natural Science at Louisiana State University (LSUMNS). These remains were excavated from 43 primary and secondary burials in Midden A in 1941 by Doran (Ford and Quimby 1945), although Lewis (1991, 1998) indicates that skeletal remains were gathered from 51 proveniences in Midden A and B, eight of which were two-person interments. This discrepancy may be the result of burials not reported by Ford and Quimby. Lewis (1991) states that she conducted research on 58 individuals in this collection, which range in age from approximately three years to between 50 and 60 years.

Sex and age estimates of remains were conducted by Lewis (1991) using a multifactorial approach. To assess sex in the fragmented collection, Lewis made numerous measurements of the femora, tibiae, patellae, humeri, crania, and mandibles as they were available for each individual. Additionally, clavicles and elements of the hands and feet were assessed for robusticity or gracility, and available pubic sympheses and sciatic notches were also considered in determining sex, using Phenice (1969) and Meindl *et al.* (1985a, b). Individuals lacking measurement sites were seriated with the larger skeletal sample to determine their sex. Out of the 55 sets of skeletal remains to which Lewis (1991) could assign sex, 27 were determined to be male, and 28 were determined to be female.

Estimations of age were made in ten-year ranges, also using a multifactorial approach. Dental data were analyzed using methods from Lovejoy (1985). The auricular surfaces of the ilia were scored following Lovejoy *et al.* (1985a). Ectocranial sutures were used based on

Meindl and Lovejoy (1985b). Two available pubic symphyses were analyzed utilizing data from Meindl *et al.* (1985b). These methods were further enhanced by the use of long bone x-rays to observe involution of the trabeculae, using data from Walker and Lovejoy (1985). Lewis (1991) also notes that osteoarthritis was considered in creating age estimates, but that the young age of some individuals exhibiting osteoarthritis in the population complicated its use as an aging tool.

Of the 51 individuals to which she was able to assign an age range, Lewis (1991) recorded that approximately two-thirds of the population were over 40 years of age. Only three individuals were determined to be 20 years old or younger at the time of death, two of which were under the age of ten (Lewis 1991). Out of the 55 skeletal remains to which Lewis (1991) could assign sex, 27 were determined to be male, and 28 were determined to be female.

This thesis is a report on 38 individuals from the Tchefuncte site, six of which have neither sex nor age information, and one of which has information on age, but not sex (Table 1). The 38 sets of remains reflect those in the collection with intact upper limb articular elements that could be scored for presence of osteoarthritis. Individuals without either sex or age information comprise 18.4% ($n = 7$) of the sample population. Of those 31 individuals for whom sex and age are both available, 17 (44.7%) are females and 14 (36.8%) are males (Table 1). The preservation of the sample is good, but the skeletal remains are fragmentary and incomplete. All individuals with any available joint surfaces were included in the study.

Table 1. Sex and age estimation of skeletal sample from the Tchefuncte site.

Age	Male	Female	N/A	Total
20-30	2	1	-	3
30-40	4	4	1	9
40-50	6	4	-	10
50+	2	8	-	10
N/A	-	-	6	6
Total	14	17	7	38

Methods

Data were gathered on the presence of osteoarthritis in adults (aged approximately 20 years or older) at the glenoid fossae of the scapulae, the distal and proximal ends of the humeri, and the distal and proximal ends of the radii and ulnae. The acromion process of the scapula also was examined; however, the Tchefuncte site skeletal collection contained no acromion processes with intact articular surfaces. Therefore, this joint surface was excluded from analyses and results. The joints of the upper limbs were chosen for study due to the mix of factors, including age and physical activity, which may result in osteoarthritis forming at these sites. While osteoarthritis at the shoulder is correlated with age, the elbow is more correlated with activity (Bridges 1992; Jurmain 1977, 1990; Ortner 1968), which may allow for a separation of age verses activity related osteoarthritis for the individuals living at the Tchefuncte site.

Following Ubelaker's (1999) methodology, the presence of osteoarthritis was scored on a four-point (0-3) scale (Table 2). On this scale, a "0" indicates no evidence of osteoarthritis, a "1" indicates the slight formation of osteophytes (lipping) at the joint, a "2" indicates moderate lipping and/or pitting of the bone, and a "3" indicates the presence of severe lipping, pitting, and/or eburnation at the joint (Ubelaker 1999). Additionally, elements without an intact articular surface were given a score of "9" and excluded from the results.

The 38 adults from which osteoarthritis data were gathered all had at least one element with a relevant joint surface available for scoring. Due to the small size of the sample population, all elements were considered as long as some part of the articular surface was intact, and each element was given a score based on the completion of the joint surface (Table 3). Additionally, elements were scored from both left and right sides, as the fragmentary condition of the remains would have rendered the sample significantly smaller if limited to a single side or a larger articular surface area (Table 4). Related joint elements were preserved in one individual, but most individuals had single or unmatched elements. Each element therefore received the highest score present on any part of the available joint surface.

Table 2. Scoring for presence of osteoarthritis.

Score	Description
0	None
1	Slight lipping and/or pitting
2	Moderate lipping and/or pitting
3	Severe lipping, pitting, or eburnation
9	Not scorable

Table 3. Scoring for completeness of articular surface.

Score	Description
X	Not available
1	< 25%
2	25-75%
3	> 75%

Data were assessed statistically wherever possible using the Fisher's Exact Test. Differences in the overall frequencies of osteoarthritis were examined between the sexes, by side, and by age for each joint surface (i.e., glenoid fossa, proximal humerus, distal humerus, etc.). Additional analyses were conducted to examine differences among varying combinations

of scores, such as by joint or limb. For example, the glenoid fossa and proximal humerus were categorized together as “shoulder,” the distal humerus and proximal radius and ulna were categorized as “elbow,” and the distal radius and ulna were categorized as “wrist.” These aggregate scores then were examined for differences by sex and age group. Finally, the frequency of osteoarthritis was compared to Lewis’s data on treponemal disease. For all tests, significance was determined if $p < .05$.

Table 4. Number of available elements by side, age, and sex.

Surface	Female				Male				Total
	20-30	30-40	40-50	50+	20-30	30-40	40-50	50+	
LGF	-	1	-	-	1	1	-	-	3
RGF	-	1	-	-	-	1	1	-	3
LPH	-	-	1	-	1	-	1	-	3
RPH	1	1	-	-	1	-	1	-	4
LDH	-	2	3	1	2	4	3	1	16
RDH	-	3	-	4	2	2	2	2	15
LPR	-	1	1	4	1	1	3	1	12
RPR	-	-	-	4	2	-	3	1	10
LDR	-	3	-	-	2	1	3	1	10
RDR	1	-	-	-	1	1	3	1	7
LPU	-	2	2	1	1	3	3	1	13
RPU	1	3	-	4	2	1	2	2	15
LDU	-	1	-	-	1	1	1	-	4
RDU	-	2	-	1	1	-	3	-	7
Total	3	20	7	19	18	16	29	10	122

Surface abbreviations are marked by an initial L or R for left or right side. GF = glenoid fossa, PH = proximal humerus, DH = distal humerus, PR = proximal radius, DR = distal radius, PU = proximal ulna, and DU = distal ulna.

Chapter Four: Results

Fourteen articular surfaces from the upper limbs were examined in this study. Thirty-eight individuals in the population had at least one relevant articular surface available for scoring. Because most individuals were incomplete, the actual number of articular surfaces scored was 129 (including the seven individuals with neither sex nor age information), rather than the potential 532 surfaces. Furthermore, of the 129 surfaces examined, 88 (68.2%) had less than 25% of the articular surface available for analysis (Figure 1). Thirty-four (26.4%) had 25-75% of the articular surface present and only seven (5.4%) had an articular surface greater than 75% represented.

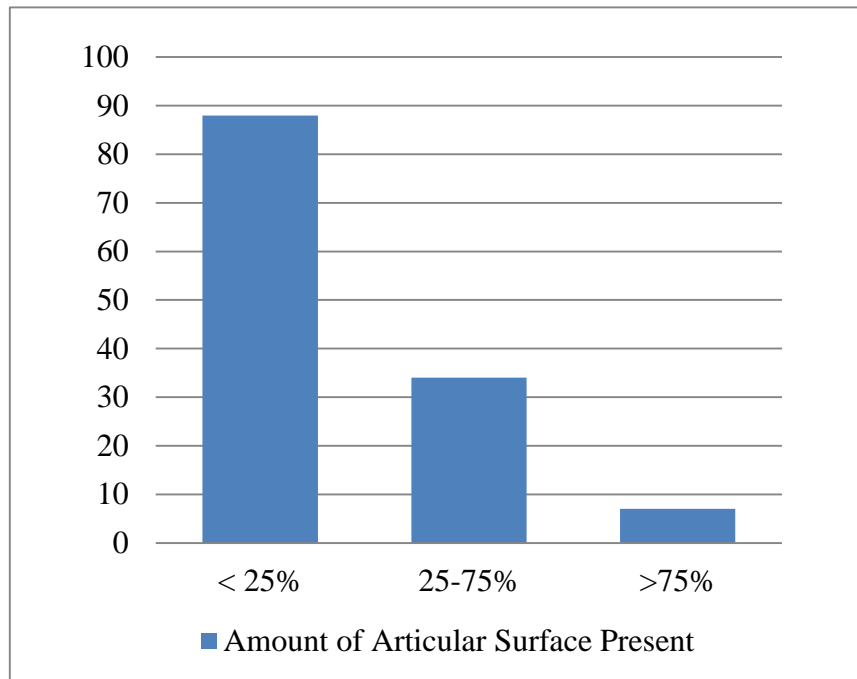


Figure 1. Proportion of available joint elements in each category.

The number of surfaces scored per individual ranged from one to 13, with the mode being one ($n = 12$), the median 2.5, and the mean 3.4. Figure 2 shows the distribution of scorable surfaces in the Tchefuncte sample. Thirty-two of 38 (84%) individuals in the sample had five or fewer scorable articular surfaces. The most commonly preserved surface was the right proximal

ulna ($n = 17$), followed by the right and left distal humeri ($n = 16$ and 15 , respectively) and the left proximal ulna ($n = 14$) (Figure 3).

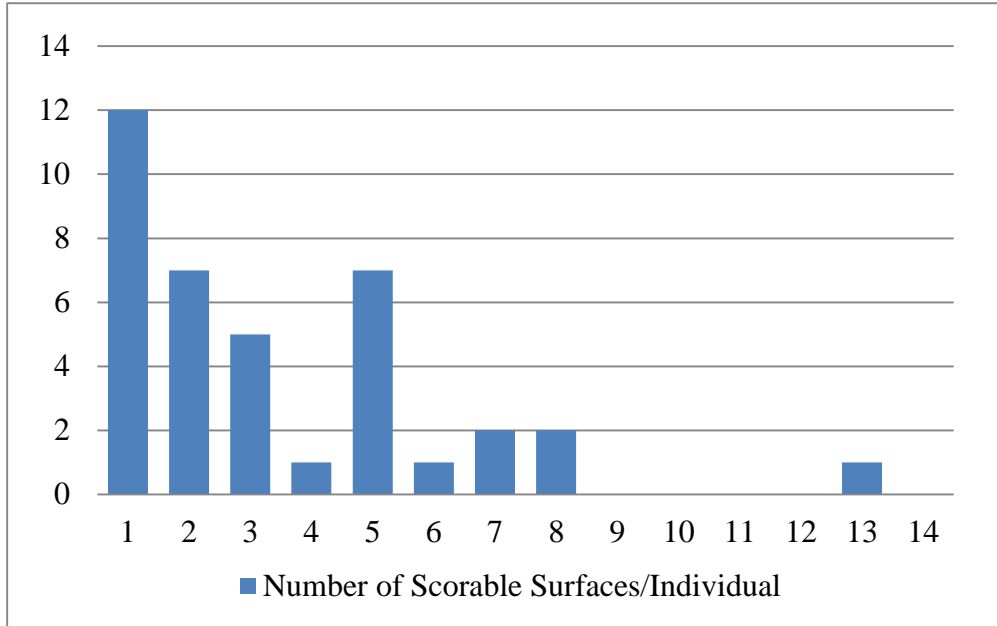


Figure 2. Number of scorable surfaces per individual.

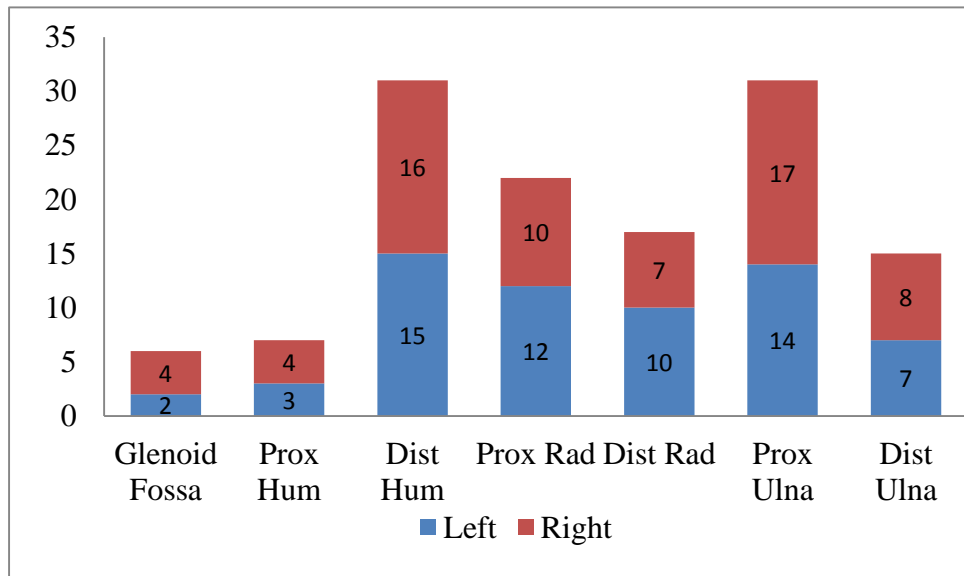


Figure 3. Number of available articular surfaces, by side and element.

The frequencies of osteoarthritis in joint surfaces from the left and right sides were examined for differences statistically. Eleven of 58 (18.9%) left elements had surfaces which exhibited osteoarthritis, while 17 out of 66 (25.8%) right elements exhibited osteoarthritis. This difference in frequency of osteoarthritis between the sides was not significant ($p = .3971$); therefore, left and right sides were combined for all other analyses.

Table 5 presents the distribution of osteoarthritis in the Tchefuncte sample divided by age category and sex. Within the study sample, 20 out of 38 (52.6%) individuals had at least one element exhibiting any sign of osteoarthritis. When separated by sex, eight out of 17 (47%) females and 10 out of 14 (71.4%) males exhibited osteoarthritis on at least one joint surface. This difference in the frequencies of osteoarthritis between males and females was not significant ($p = .157$). When separated by age (sexes combined), the frequency of osteoarthritis was two out of three in the youngest group (20-30 years, 66.6%), six out of nine (66.6%) in the 30-40 year group, six out of 10 (60%) in the 40-50 year group, and four out of 10 (40%) in the oldest group (50+ years). These differences also were not significant ($p = .6569$). A separate set of analyses examining age differences within each sex and sex differences within each age category also yielded no significant results (p values presented in Table 5, in the last column and row, respectively).

Table 6 presents the frequencies of osteoarthritis by joint surface for both sexes and all age categories. Though just over half of the population exhibits osteoarthritis, the majority of these individuals ($n = 18$ or 90%) have the lowest severity (score “1”). Only one individual received a score of “2” (moderate osteoarthritis) on one joint surface (a male, aged 20-30 years, on the left glenoid fossa) and one individual received a score of “3” (severe osteoarthritis) on two joint surfaces (a female, aged 50+ years, on the right distal humerus and proximal ulna).

Table 5. Frequencies of osteoarthritis in the Tchefuncte sample divided by sex and age.

Age Category	20-30	30-40	40-50	50+	N/A	Total	Age within Sex
Males with OA	2	2	5	1	0	10	0.4945
Males without OA	0	2	1	1	0	4	
Females with OA	0	4	1	3	0	8	0.1085
Females without OA	1	0	3	5	0	9	
N/A with OA	0	0	0	0	2	2	
N/A without OA	0	1	0	0	4	5	
Total Males	2	4	6	2	0	14	
Total Females	1	4	4	8	0	17	
Total N/A	0	1	0	0	6	7	
Total with OA	2	6	6	4	2	20	0.6569
Total # Individuals	3	9	10	10	6	38	
p-values	0.3333	0.4286	0.1905	>.9999			

Results of the analyses which combined scores from multiple surfaces into their respective joints are presented in Table 7. At the shoulder, one out of five surfaces in females and four out of seven surfaces in males exhibited osteoarthritis. At the elbow, nine out of 36 surfaces in females and seven out of 44 surfaces in males displayed osteoarthritis. Finally, at the wrist, one out of eight surfaces in females and four out of 22 surfaces in males had osteoarthritis. None of these differences between sex by joint was significant.

Table 6. Number of elements examined for and affected by osteoarthritis divided by sex and age category. Individuals without sex or age designation are excluded.

Surface	Age Cat.	Males		Females		Total	
		examined	affected	examined	affected	examined	affected
Glenoid fossa	20-30	1	1	0	0	1	1
	30-40	1	1	2	1	3	2
	40-50	1	1	0	0	1	1
	50+	0	0	0	0	0	0
Proximal humerus	20-30	2	1	1	0	3	1
	30-40	0	0	1	0	1	0
	40-50	2	0	1	0	3	0
	50+	0	0	0	0	0	0
Distal humerus	20-30	4	0	0	0	4	0
	30-40	5	0	5	2	10	2
	40-50	5	1	3	1	8	2
	50+	3	1	5	1	8	2
Proximal radius	20-30	3	1	0	0	3	1
	30-40	1	0	1	0	2	0
	40-50	6	3	1	0	7	3
	50+	2	0	8	1	10	1
Proximal ulna	20-30	3	1	1	0	4	1
	30-40	4	0	5	2	9	2
	40-50	5	0	2	0	7	0
	50+	3	0	5	2	8	2
Distal radius	20-30	3	1	1	0	4	1
	30-40	2	1	3	1	5	2
	40-50	6	2	0	0	6	2
	50+	2	0	0	0	2	0
Distal ulna	20-30	2	0	0	0	2	0
	30-40	1	0	3	0	4	0
	40-50	6	0	0	0	6	0
	50+	0	0	1	0	1	0
Total		73	15	49	11	122	26

Table 7. Number of surfaces with osteoarthritis combined into joints.

Combined Joint	Male		Female		Total Male	Total Female	Total Combined	P Value
	With	Without	With	Without				
Shoulder	4	3	1	4	7	5	12	0.5804
Elbow	7	37	9	27	44	36	80	0.4023
Wrist	4	18	1	7	22	8	30	>.9999
Total	15	58	11	38	73	49	122	0.6529

Differences in the frequency of osteoarthritis between the joints with sexes combined also were tested for significance (Table 8). For these analyses, articular surfaces were designated with presence or absence of osteoarthritis and each joint compared to the others. Although comparisons between elbow and wrist, and between wrist and shoulder did not reveal any significant differences, the comparison of shoulder and elbow did.

Table 8. Presence and absence of osteoarthritis by joint.

	Shoulder	Elbow	Wrist
OA Present	6	16	6
OA Absent	7	68	26
	$p_{SE} = .0359 *$	$p_{EW} = 1.000$	$p_{WS} = .0757$

Subscripts represent joints being compared: SE = shoulder vs. elbow; EW = elbow vs. wrist; WS = wrist vs. shoulder.

“*” indicates statistical significance.

Lastly, the relationship between the OA and treponemal disease was assessed. The 38 individuals in this study were designated as remains “with” or “without osteoarthritis.” These remains were then compared to Lewis’ (1991) study, and matched by catalogue number with those she determined had pathological bone (“with treponematosi”) or which were unlisted and

presumed unaffected by disease (“without treponematosi s”) (Table 9). The relationship between the frequencies of the two conditions was not significant.

Table 9. Number of individuals designated with or without osteoarthritis and treponematosi s.

	With Treponematosi s	Without Treponematosi s	Total	P Value
With Osteoarthritis	18	3	21	
Without Osteoarthritis	11	6	17	
Total	29	9	38	
P Value				0.2493

Chapter Five: Discussion and Conclusions

Discussion

Osteoarthritis is one of the more commonly recorded pathologies found in skeletal populations. The presence of osteoarthritis, while formed by many etiologies, is likely related in part to activity. In particular, osteoarthritis at the elbow joint is strongly correlated with activity, while the shoulder joint seems to be correlated more with biological age. For these reasons, the upper limbs are ideal sites of study, providing information about the population-level prevalence of the disease, as well as data regarding regular physical stressors. In order to contribute to the larger scholarship on Native American lifeways, this study of osteoarthritis at the Tchefuncte site is an attempt to gather information about the activities of the population which lived there during the Tchula period.

Difficulties due to the small size of the sample were further compounded by the incompleteness of the individuals and the poor preservation of the available articular surfaces. Thus, drawing overarching conclusions regarding disease and activity in the population of the Tchefuncte site was difficult. In a sample of 38, no single individual had all 14 surfaces available for scoring, though one individual, a male aged 20-30 years had 13 (he was missing only the right glenoid fossa). Most individuals had only one surface available for analysis. For example, though 76 glenoid fossae should be available for scoring in a sample this size, only six partial glenoid fossae were present, five of which were scored “1” or higher for the presence of osteoarthritis. The elements with the greatest number of preserved surfaces were the right proximal ulna (17 surfaces, four scored “1” or higher), the right distal humerus (16 surfaces, three scored “1” or higher), and the left distal humerus (15 surfaces, three scored “1” or higher).

These surfaces all contribute to the elbow joint. Also, there is almost no overlap between individuals regarding which elements exhibit osteoarthritis.

Furthermore, most of the surfaces available had less than 25% of the articular surface represented; only 5% ($n = 7$) of the surfaces examined were mostly complete. Thus, the incidence of osteoarthritis is likely underestimated in this sample. These differences in preservation may contribute to a skewed interpretation of the roles of age and activity in the etiology and incidence of osteoarthritis. Therefore, a discussion of each joint is warranted.

Presence of osteoarthritis at the shoulder has been positively correlated with age in other studies (Bridges 1992; Jurmain 1977, 1980, 1990). Although no such relationship was found in this study, several general comments can be made. First, examination of the shoulder joint elements overall yielded few instances of osteoarthritis, but those that do exist are not found in the oldest age group. The general absence of the joint in this sample may point to the highly diseased and deteriorated nature of the joint in many individuals in this population at time of death. Alternatively, the absence could be due to the fragility of the articular margins in the relevant elements as a result of taphonomic processes, excavation damage, or post-excavation/curatorial effects. The 13 shoulder elements present in this collection represent eight individuals, five of which exhibit osteoarthritis at the shoulder joint. Three of those individuals are male, and none are estimated to be older than 50 years. In fact, the most severe expression is in the youngest individual, a 20-30 year old male with two osteoarthritic shoulders. A second comment worth noting about the prevalence of osteoarthritis in the shoulder in the Tchefuncte sample is that the level of osteoarthritic development is inconsistent in the various elements that combine to form the joint. Specifically, three instances are found in which sets of elements form a complete shoulder joint (i.e., a left glenoid fossa and a left proximal humerus), but these

complete sets do not exhibit the same degree of osteoarthritic development on both elements of the joint.

The most dramatic example of the inconsistent osteoarthritic development with age or within a joint in this population involves #15085, the young man noted above. Despite his young age at death, he received the highest score of all present elements of the shoulder joint (i.e., a “2” at the left glenoid fossa). The articulating element, the left proximal humerus, also is present with similar completeness, yet it does not exhibit any osteoarthritic development. Therefore, this individual is unusual for two reasons: 1) he does not fit the expectation that heavier osteoarthritis scores would be found in older individuals; and 2) he does not fit with the other individuals in this population who are affected with osteoarthritis in the shoulder; they all have mild cases, his case is more severe. These atypical results might indicate that the osteoarthritis present in this individual’s shoulder is related to trauma that occurred because of an active lifestyle, rather than to activity *per se*. For example, if males took part in hunting as a subsistence strategy, this young man may have sustained either a single injury to his shoulder while hunting or could have suffered from more regularly occurring minor trauma sustained during everyday activities (Dabbs 2011; Weiss and Jurmain 2007). The fact that this individual also has 12 other articular surfaces present, only two of which show mild osteoarthritis (the right proximal humerus and left proximal ulna), further supports the interpretation that the moderate case in his left shoulder is injury related. However, aside from the severe osteoarthritis, the scapula and humerus of this individual show no obvious antemortem trauma. Additionally, Lewis (1991, 163) noted that this individual exhibited “[v]ery little pathological involvement” (Lewis 1991, 163) and, thus, this person was not diagnosed with strong signs of treponematosis. Yet, he nevertheless died at a very young age. Considering Wood *et al*’s (1992) “osteological paradox,” the interpretation

cannot be ruled out that #15085 was a highly diseased individual who died quickly from virulent disease or a weakened immune system.

Osteoarthritis of the elbow is linked to activity in several studies (Bridges 1992; Jurmain 1977, 1980, 1990; Ortner 1968). A total of 84 elements from the elbow joint are present in this sample. Of those, 16 (19%) have osteoarthritis and all but two received a score indicating low severity (a “1”). The two elements which did not, received a score of “3” and are found in the same individual, a female (#16643) aged 50+ years, who exhibits pitting, osteophyte formation, and eburnation on the right distal humerus and proximal ulna. Both of these elements were less than 25% present, yet the osteoarthritis was clearly observable; none of her left side was present. Three other females in this age group had these same elements preserved, yet none exhibited this level of osteoarthritis (in fact, only one individual had low severity (“1”) osteoarthritis in a proximal ulna). The high score at this joint for #16643 may indicate that this individual’s workload was heavier, or took place over a longer period of time, than other individuals in her cohort. Additionally, preservation may affect results and interpretation; poor preservation of 50+ female remains probably do not accurately reflect joint wear for this sex and age group for the population. Lewis (1991) makes no particular mention of #16643, though non-arthritic lesions are present at both sites of arthritic development.

For the Tchefuncte sample, although the elements which form the elbow joint are present in far greater number than the elements of the shoulder, the percentage of diseased elements is lower. As noted above, only 16 (19%) out of 84 available elements exhibit signs of osteoarthritis. Incidence of osteoarthritis at the shoulder is 46.1% (six diseased elements out of 13). The lower number of diseased elbow elements overall implies a lower incidence of osteoarthritis in the population than the shoulder suggests. The statistically significant difference

($p = .0359$) between the two joints may be further evidence that the etiology of osteoarthritis at each joint differs somewhat, and depends on where it develops. Alternatively, the difference in prevalence rates between the shoulder and elbow joints may be an artifact of their vastly different sample sizes.

The wrist joint remains enigmatic in this study. Trauma may play a role in the etiology of osteoarthritis of the wrist (Jurmain 1990; Roberts *et al.* 2006), though it is likely that other factors also contribute. For samples in which the wrist shows bilateral asymmetry, it may be argued that activity plays a role in either developing or exacerbating osteoarthritis at the joint. Ortner (1968) argued that, as a non-weight bearing joint, the elbow was most likely affected by activity in the etiology of osteoarthritis, an argument which may hold true for the wrist as well. In this sample, though, only 19% ($n = 6$) of the available articular surfaces of the wrist showed any development of osteoarthritis. Four of the six articular surfaces were found on male individuals, and, thus, are indicative of activities performed by males, such as hunting or clearing land.

Finally, with regard to co-morbidity between osteoarthritis and other pathological conditions (i.e., dental disease, nonspecific indicators, and treponemal infection), some of the trends discussed by Listi (2007) may be applicable to the inhabitants of 16ST1. Caries were observed in the Pre-Coles Creek sample at frequency rates that are unexpectedly high for hunter-gatherers in North America (Listi 2007), suggesting that individuals living in the southeast depended on carbohydrate-rich plants as a main food source. The procurement of plants may have been a frequent but non-strenuous physical activity, leading to the widespread but not severe osteoarthritis seen in the sample. Additionally, regular gathering trips into uneven terrain may have contributed to low levels of trauma caused by trips and falls, which could cause some

of the more severe cases of osteoarthritis or exacerbate existing osteoarthritis. However, no evidence of antemortem trauma was found in the skeletal sample to support this supposition, and so disease, individual morphology, genetics, and body mass index should be considered as alternative factors in severity differences.

Regarding non-specific indicators of stress, Listi (2007) notes that regional differences influenced distributions of Harris lines, enamel hypoplasias, and porous lesions of the skull. Individuals living at coastal sites exhibited higher frequencies of porous lesions of the parietals, enamel hypoplasias, and Harris lines than did inland populations, which Listi (2007) suggests is related to more frequent infections due to the warmer, more humid climate of coastal regions. Lewis (1990, 1998) showed that treponemal infection was widespread at the Tchefuncte site and suggests that Lyme disease may have been present as well. While the two diseases may have each provided some immunity from the other, presence of disease likely placed stress on the population, which manifests in non-specific indicators. The two forms of treponemal disease, yaws and endemic syphilis, are often contracted in childhood, which is when non-specific indicators form, but are not thought to have contributed to mortality (Lewis 1990; Listi 2007). If contraction of treponematosi is accompanied by a period of illness, the infection may be the source of some non-specific indicators of stress.

With regard to the relationship between treponematosi and osteoarthritis in the Tchefuncte sample, it is notable that the largest group of individuals ($n = 18$, 47%) has both conditions; the smallest group has osteoarthritis but not treponemal disease ($n = 3$, 8%). In her investigation, Lewis (1990) noted but did not investigate osteoarthritis, and the two pathologies generally are not discussed together. Although yaws and endemic syphilis are non-fatal diseases, they are systemic infections which can impact bone. Of the upper limbs in the Tchefuncte site,

Lewis (1990) states that affected bone may appear to have osteoarthritis if other obvious signs of treponemal infection are not found. In particular, symptoms of syphilis which form outside of areas most typically affected by syphilis are likely to resemble osteoarthritis (Lewis 1990). However, Lewis (1990, 1995) also states that osteoarthritis may form due to “continued activity during times of systemic infection.” The high number of individuals exhibiting both osteoarthritis and treponemal infection is likely a reflection of the relationship between activity and infection in the etiology of osteoarthritis. Inhabitants of the Tchefuncte site generally exhibit low severity of osteoarthritis – perhaps observed incidence of osteoarthritis would be even less frequent if the population had not been affected by treponemal disease.

Overall, the low incidence of osteoarthritis in the upper limbs suggests that activities performed by the people at the Tchefuncte site were not as physically stressful as one might imagine. Though not agriculturalists, the population at 16ST1 had access to abundant plant, animal, and marine resources, a fact which enabled them to be relatively sedentary without relying on agriculture. Although archaeological evidence suggests the use of the atlatl, fishing nets, and metates, strenuous use of these tools is not evident in the skeletal record of the site - even though over half the individuals preserved ($n = 20$) would have represented “older” individuals (i.e., 40+ years). The heavy representation of older individuals in the sample suggests that the people living at the Tchefuncte site generally were in good health, often living to advanced ages and experiencing low levels of physical stress.

Conclusions

The presence of osteoarthritis in the population from the Tchefuncte site, 16ST1, can be used to infer something of their lifeways and typical activities. As the Tchula period has largely

been neglected in bioarchaeological literature, this research serves to contribute to the examination of that time period. The small, heavily fragmented and damaged sample precludes making firm statements about the activities of the Tchefuncte people. Nevertheless, the non-significant differences in the frequencies of osteoarthritis between the sexes or among age groups and the overall low incidence and severity of osteoarthritis are consistent with an egalitarian social structure whose physical activities only minimally impacted their upper limb joints. The significant difference in the frequency of osteoarthritis between the shoulder and elbow may be indicative of different activities impacting those joints, or the difference may be an artifact of the small sample. The few instances of moderate or severe osteoarthritis may be attributed to disease or injury, or to specialized activity in particular individuals.

Finally, the greatest limitation of this study and other bioarchaeological examinations of the Tchefuncte culture is the fragmented nature of the small skeletal collections that are available. It is difficult to form strong arguments regarding the activities of populations when so little material is available for investigation. Nevertheless, investigations of small samples can contribute to the greater literature on the culture, as well as to the literature on disease incidences and etiologies. Further study of this skeletal population is recommended, as examination of the ankle, knee, and hip may provide greater knowledge regarding the activity patterns of those who lived at the Tchefuncte site.

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